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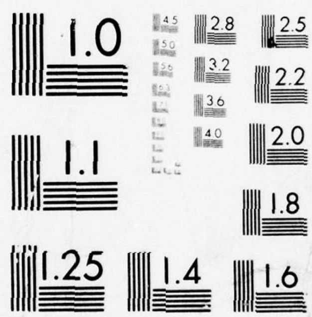

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THE UNIVERSITY OF TEXAS AT AUSTIN

29 July 1969

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QUARTERLY PROGRESS REPORT NO. 1
UNDER CONTRACT N00024-69-C-1129 (U)

1 January - 31 March 1969

NAVAL SHIP SYSTEMS COMMAND
Contract N00024-69-C-1129
Proj. Ser. No. SF 11121100
Tasks 8103, 8212, 8515

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QUARTERLY PROGRESS REPORT NO. 1, UNDER CONTRACT N00024-69-C-1129 (U)

1 January - 31 March 1969

15 NAVAL SHIP SYSTEMS COMMAND
Contract N00024-69-C-1129
Proj. Ser. No. SF 11121100
Tasks 8103, 8212, 8515

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I. Project Serial No. SF 11121100, Task 8103

A. AN/SQS-23 SME-PME Playback Program
(L. A. Jeffress)

(U-~~FOUO~~) Data collection in the clue evaluation study is now completed. Two subjects were used to evaluate four clues (echo strength, onset, duration, and multiplicity) as submarine/nonsubmarine classifiers. Each of the clues was rated separately in both the visual and the auditory modalities on a 10-point rating scale. For each clue/modality combination, each subject made rating responses to each of 15 successive pings on each of 62 segments of taped sonar training material. Approximately 50% of the targets used were submarines, the remainder being nonsubmarine targets.

(U-~~FOUO~~) As originally planned, the data were used to obtain ROC curves for the several clue/modality combinations used. Preliminary results indicate that all the clues except onset or rise-time yield better-than-chance classification. The clues will be examined for independence by finding the correlation coefficients between the responses on a segment-by-segment basis.

Monaural and Binaural Electrical Models of Auditory Detection
(P. I. Williams and L. A. Jeffress)

(U-~~FOUO~~) This study will be used as the basis for a doctoral dissertation. The research has been completed and is being prepared for clearance as a dissertation and for publication.

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Computer Simulation of Auditory Detection
(A. D. Gaston and L. A. Jeffress)

(U-~~FOUO~~) This study is being prepared for clearance as a doctoral dissertation and for publication.

B. Naval Ship Systems Command Sonar Display Advisory Panel
(C. L. Wood)

(U-~~FOUO~~) Dr. C. L. Wood has replaced Dr. L. A. Jeffress on the Sonar Display Panel. The Panel has planned its next meeting in Raleigh, North Carolina, on 16 April 1969.

[redacted]

II. Project Serial No. SF 11121100, Task 8212

A. Echo Recognition
(K. J. Diercks)

1. Space-Time Echo Analysis

U In Quarterly Progress Report No. 4 under Contract N00024-68-C-1117 (U) (1 October - 31 December 1968), a different technique for processing LFM STARLITE data was described. Spatial samples of the echoes from a line target were compressed by cross-correlating each with a stored replica of the transmitted signal. Echo compression recovered the range resolution which was sacrificed by using a long FM transmission. The Fourier spectrum of each compressed echo was computed and the spectra of paired samples were crosscorrelated to determine the frequency shift between them. This shift was then used in the STARLITE equations to estimate target aspect.

U The results of this compressed echo processing of data recorded for the ARL Single Line Target were presented in a correlation track plot, which is repeated here as Fig. 1. The aspect dependence of the frequency shift measurement is evidenced by the track that is generated by the peaks of the complex crosscorrelation functions. The solid curve identifies the theoretical frequency shift value for each aspect (for the parameter values shown). Also apparent in this figure are several false tracks generated by the side lobes of the correlation functions. (The existence of a track--false or true--indicates a line-like target; however, a false track yields incorrect estimates of target aspect and, perhaps, direction.)

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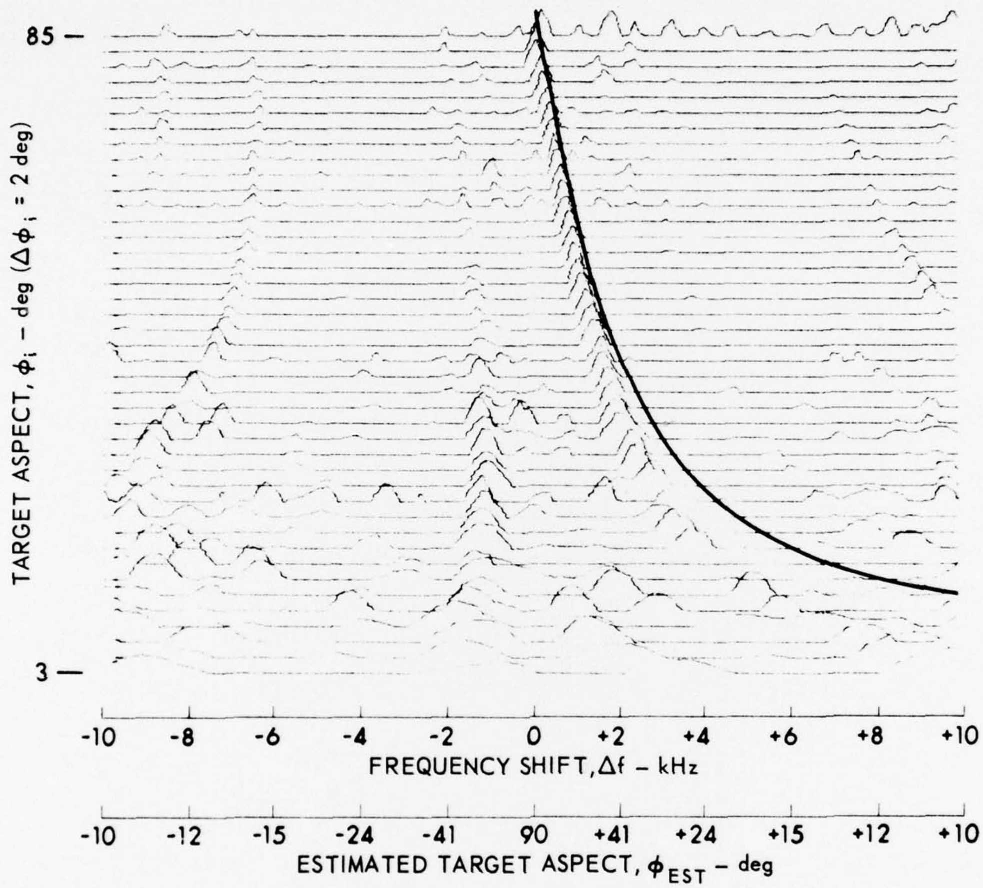


FIGURE 1
ARL STARLITE COMPRESSED ECHO
CROSSCORRELATION TRACK PLOT (U)
SINGLE-LINE TARGET S/N > 30 dB
T = 5 msec f_0 = 220 kHz W = 20 kHz B = 0.35 m R = 22 m
PLOTTING THRESHOLD: 0.5

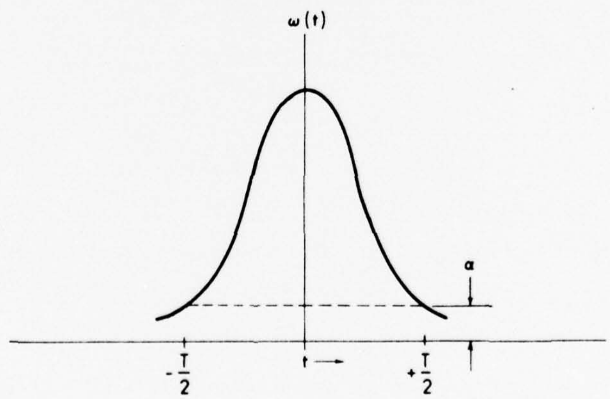
ARL - UT
AS-69-100
KJD - RFO
1 - 23 - 69

(U) A first attempt at side lobe suppression by amplitude-thresholding each plotted correlation function was reported in QPR No. 4 under Contract N00024-68-C-1117 (U). The results showed that, whereas the side lobe tracks could be eliminated by amplitude-thresholding, many of the true correlation peaks were also lost, especially at the lower aspect values (near beam), thus degrading the true track.

(U-~~FOUO~~) Subsequently, during this reporting period, further attempts to achieve side lobe suppression by signal weighting, or by different processing, were performed. The Hamming weighting function, given by

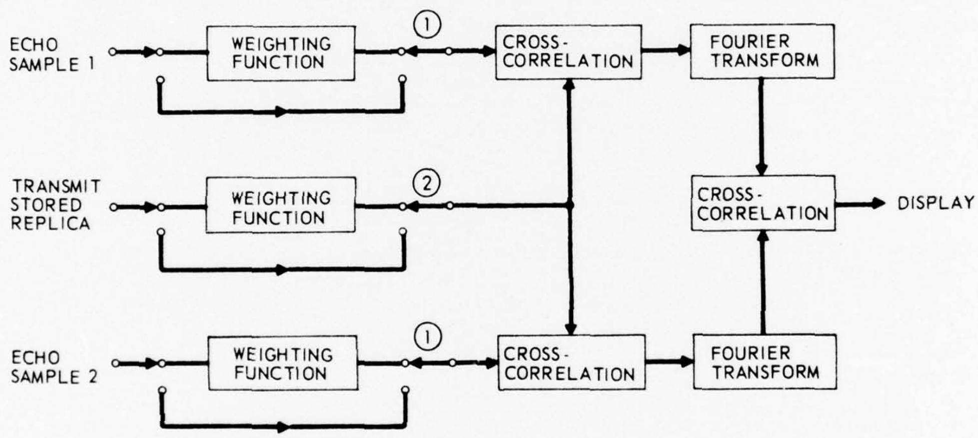
$$\omega(t,\alpha) = \alpha + (1-\alpha) \cos \frac{2\pi t}{T} ,$$

was used. The parameter T is the signal length; α is a constant which describes the functional "pedestal". Diagrammatically, this is



(U-~~FOUO~~) The function, and the theoretical side lobe suppression which may be achieved for specified parameter values, is described in a paper by C. L. Temes, "Side-Lobe Suppression in a Range-Channel Pulse Compression Radar," (IRE Transactions on Military Electronics, April 1962).

(U) Implementation of the compressed echo processing technique, and the weighting applied, is diagrammed below:



Three weighting cases were implemented: Case 1, echo signals only; Case 2, transmit signal only; Case 3, echo and transmit signals. The side lobe suppression achieved by weighting the echo signals only (Case 1) of the data for Fig. 1 is illustrated in Fig. 2. The format and the parameter values of Fig. 2 are the same as for Fig. 1. There are no significant differences between the displays of Figs. 1 and 2. It is felt that the reasons for this are that the echo signal is not confined to an isolated range channel, as the theory requires, and

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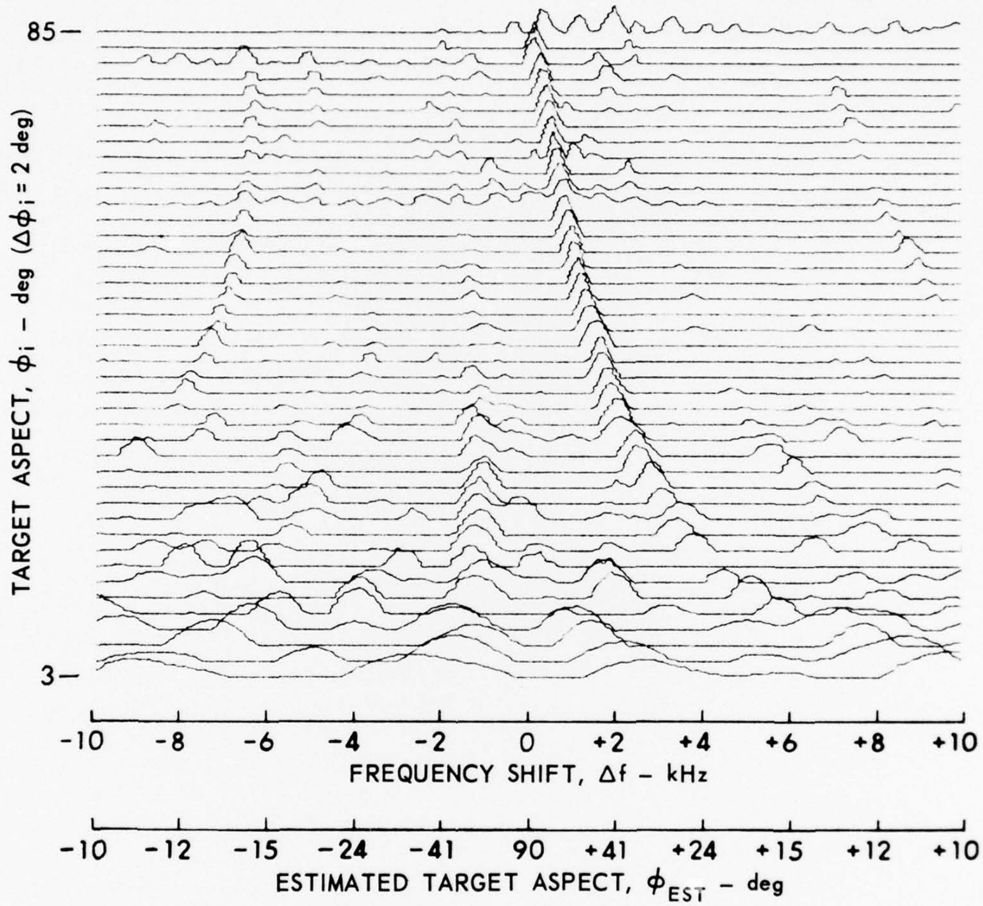

FIGURE 2
ARL STARLITE COMPRESSED ECHO
CROSSCORRELATION TRACK PLOT (U)
WEIGHTED ECHO SIGNALS

ARL - UT
AS-69-523
KJD - EJW
5 - 27 - 69

[redacted]

U (~~C~~) that the echo signal has already been weighted by the temporal response of the target (the two causes are interrelated).

U (~~C~~) The results of Case 2 weighting (transmit signal only) for these same data are illustrated in Fig. 2. There is some suppression of the distal side lobes, but there is also a degradation in the true track at the lower aspect values due to loss of correlation peaks along this track. The centrally located side lobe track predominates in this aspect region (this also occurred at the higher amplitude thresholds reported in QPR No. 4 under Contract N00024-68-C-1117 (U)).

U (~~C~~) The results of Case 3 weighting (echo and transmit signals) are illustrated in Fig. 4. There is no significant difference between these results and those of Fig. 3; but this was not unexpected since weighting the echo signals alone had little effect upon the results.

U (~~C~~) Hence, it is concluded that Hamming weighting of the transmit signal yields improved side lobe suppression but, for these data, with a degradation in the true track at the lower aspect (near beam). However, other data need be similarly processed for a more complete evaluation of the improvements and degradations resulting from weighting.

U (~~C~~) It was felt that the basis of the high side lobes evidenced in Fig. 1 lay in the phase spectra included in the complex crosscorrelation performed to yield the output display. This basis was omitted by computing the power spectrum of each compressed echo and then crosscorrelating the envelopes of the power spectra. The results of this processing, for the data of Fig. 1, are shown in Fig. 5. No signal weighting was applied. The earlier perceived side lobes are not apparent in this figure, and that they are not supports the assumption that their basis is in the phase spectra. Also, the collection of correlation peaks in the lower center of the display no longer resembles a well defined track. However, the true track is

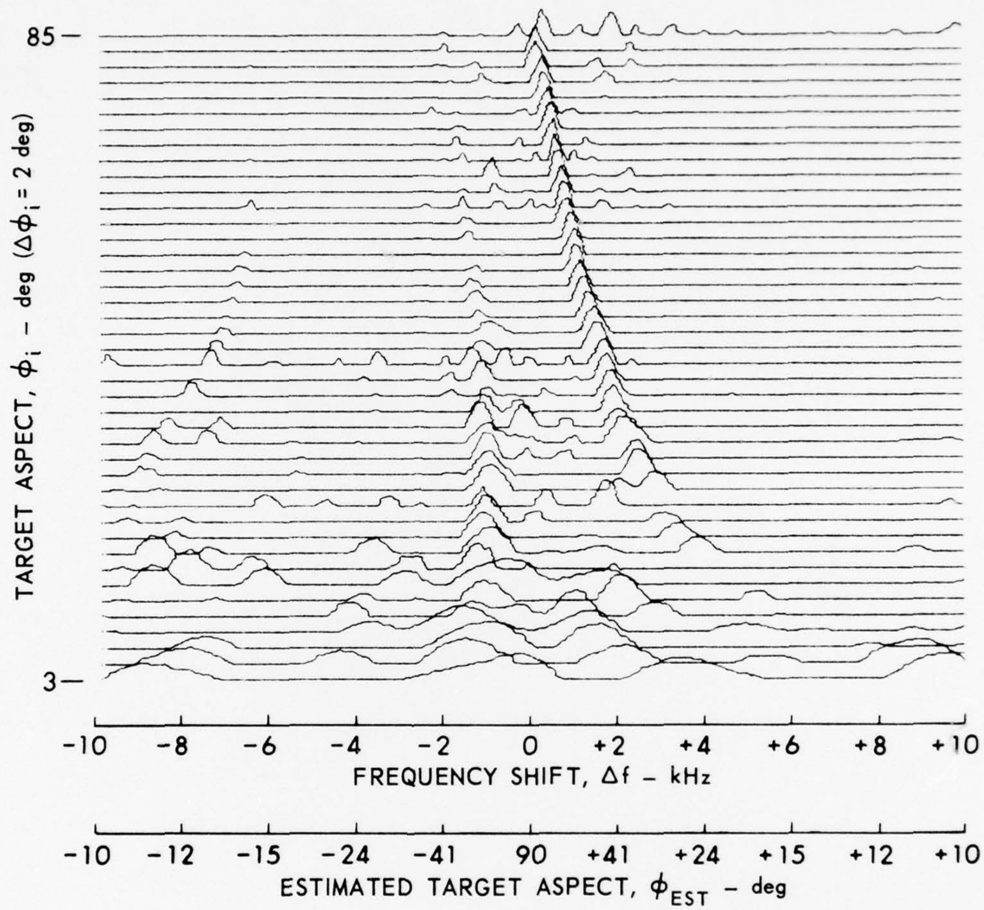

FIGURE 3
ARL STARLITE COMPRESSED ECHO
CROSSCORRELATION TRACK PLOT (U)
WEIGHTED TRANSMIT SIGNAL

ARL - UT
AS-69-524
KJD - EJW
5 - 27 - 69

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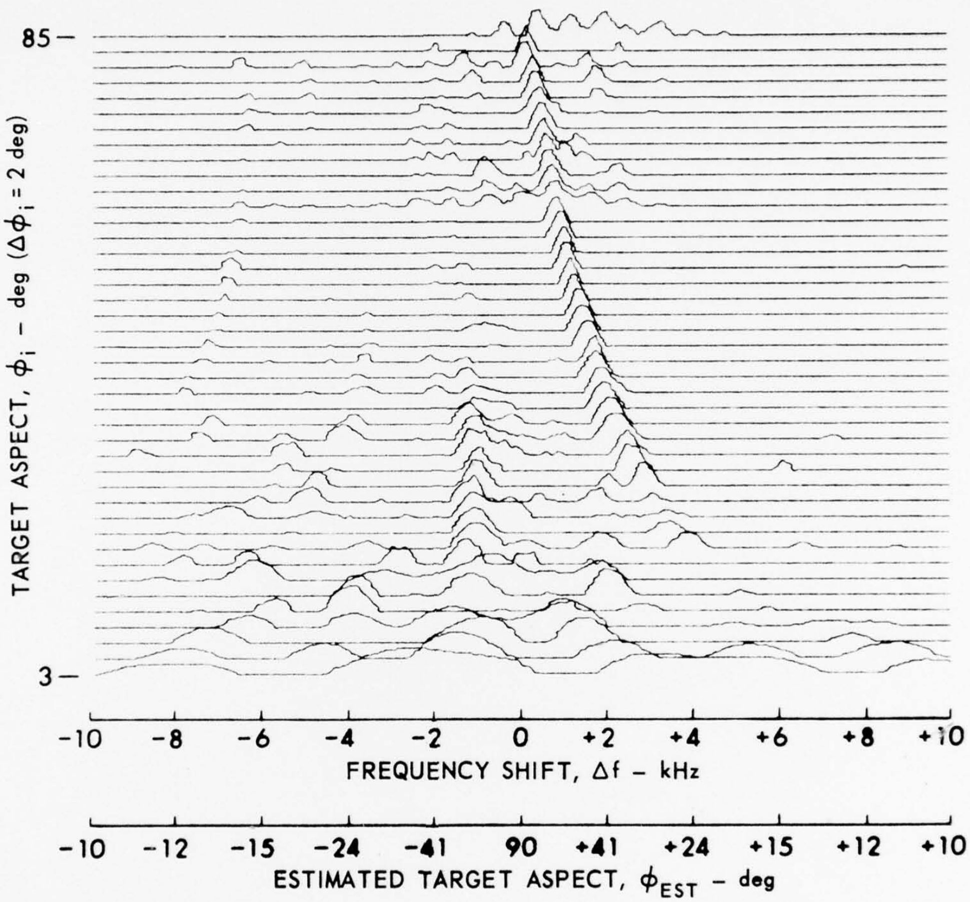

FIGURE 4
ARL STARLITE COMPRESSED ECHO
CROSSCORRELATION TRACK PLOT (U)
WEIGHTED TRANSMIT AND ECHO SIGNALS

ARL - UT
AS-69-525
KJD - EJW
5 - 27 - 69

[redacted]

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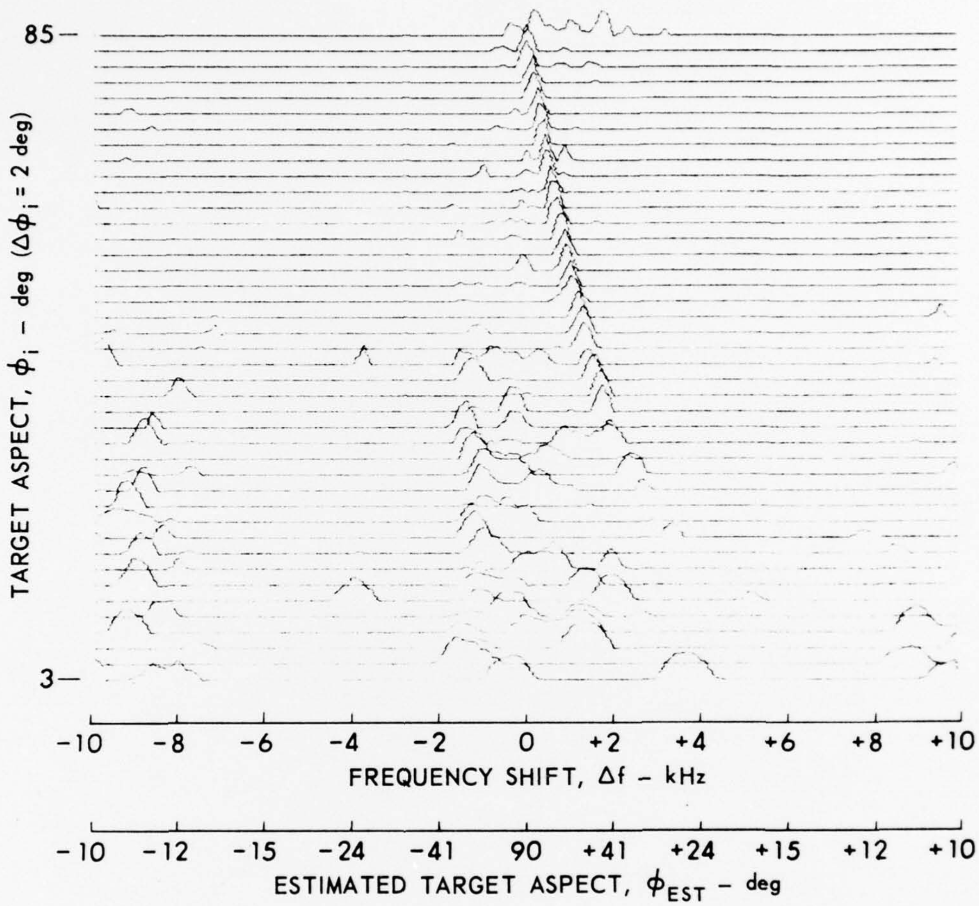


FIGURE 5
ARL STARLITE COMPRESSED ECHO POWER SPECTRUM
NOVELCOR TRACK PLOT (U)
SINGLE LINE TARGET
T = 5 msec f_0 = 220 kHz W = 20 kHz B = 0.35 m R = 22 m
PLOTTING THRESHOLD: 0.5

ARL - UT
AS-69-526
KJD - EJW
5 - 27 - 69

[redacted]

(U) effectively lost for aspect values less than 27 deg. (The latter result is consistent with other results obtained by space-time envelope processing.) Other data need to be similarly processed for a more complete evaluation of this technique.

(U-[redacted] Further investigations of signal weighting and correlation processing will be performed during the next quarter using data obtained from the ARL model of the USS SKIPJACK (SSN 585).

(U-[redacted] Because of a backlog of reports in the Technical Reports Office, DRL Technical Memorandum No. 68-25, "Digital Processing for a STARLITE Experiment with Scaled AN/SQQ-23 (PAIR) Parameters" (U), by T. G. Goldsberry and K. J. Diercks, will not be issued until next quarter.

2. Acoustic Model Studies

(U-[redacted] Recording of data from the SKIPJACK model began during this reporting period. Transducer elements for scaling 5 kHz frequency were not received until 31 March, so that all measurements recorded to date were performed at scaled 11 kHz. For these data the target is located at scaled 3 kyd range and scaled 285 ft depth. The sonar is at scaled 44 ft depth. Projecting and receiving beamwidths are 10 deg (-3 dB). A test hydrophone is located at target range 10 deg off target bearing. A second test hydrophone is located "over the bow". Use of two test hydrophones permits determination of signal multipaths by phase comparison of the near and far signals.

(U-[redacted] A two sensor sonar configuration, with the transmitter and one of the receivers colocated, was used. Both tone burst and LFM transmissions are generated. The transmission rate is one per degree of aspect change. The range of tone burst signal durations, T, was 1 msec to 120 msec, scaled, in multiples of 2 times the shortest duration, plus intermediate operational sonar values. Simulated ASPECT

(U-FOUO) is used for $T \leq 5$ msec; a burst of 10 pulses occurring at a rate of 100/sec is a transmission. Two LFM signal durations have been recorded: scaled 160 msec and scaled 500 msec. The FM bandwidths, W, are 455 Hz, 910 Hz, and 1820 Hz, scaled, which yield a minimum time bandwidth (TW) product of 73 and a maximum product of 910. Split housetop transmissions--an FM up signal followed after a short duration by an FM down signal--are included.

(U-FOUO) Measurements were recorded for 370 deg of target aspect change for most signal forms; the target was turned around a vertical axis normal to its long dimension at a rate of 1 deg/sec. Measurements were also recorded for all pulse lengths and W = 910 Hz, as selected aspect values with the target not turning.

(U-FOUO) Ten data or timing signals were recorded: electrical driving signal (stored replica), high gain and low gain levels for each receiver channel, far test hydrophone, near test hydrophone, zero time pulse, target isolation gate, and reference frequency signals. Five data tapes were recorded before it was discovered that the recorder heads were incorrectly aligned and only four signals were being satisfactorily recorded: stored replica, one high gain receiver channel, target isolation gate, and a reference signal. These tapes are being used by the Systems Analysis Section of Signal Physics for monostatic signal analyses, but they are of no use for space-time echo analysis.

(U-FOUO) While the preceding recorder misalignment was being corrected and the recorder recalibrated, four turning-target STARLITE runs were recorded at one gain level only, using a 7-channel machine. Two single pulse and two split housetop transmission runs each were recorded. These data are being processed--some program modifications are required--and the results will be included in the progress report for the next quarter.

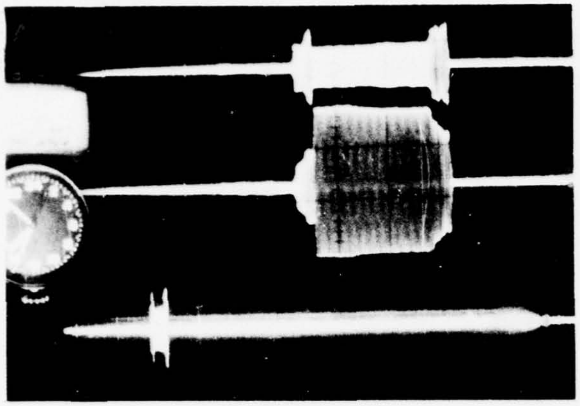
(U-[redacted]) One, two, or three data signals for <u>each</u> transmission are simultaneously displayed on an oscilloscope during recording, and this display is recorded on 35mm film. Selected examples from the photographic record that illustrate the kind and quality of data being recorded are shown in Figs. 6 through 9.

(U-[redacted]) Polar plots of the angular dependence of the relative target strengths of the SKIPJACK model were obtained from film records. Two 360 deg turning runs at scaled 11 kHz were plotted. For these runs the target was at scaled 550 ft depth, with the sonar at scaled 300 ft depth. Scaled 2 msec and 30 msec tone burst transmissions were used. For the short transmission the peak value only of the echo was plotted. These results are displayed in Fig. 10. This is a composite of measurements from two resolutions of the target, the first recorded at a reference gain and the second recorded at a lower gain to obtain a valid reading of the echo levels near beam aspect. For the longer transmission the peak and average values of the echoes were plotted (a subjective estimate of "average" was used). These results are displayed in Figs. 11 and 12. Figure 11 shows the angular dependence of peak relative target strength; Fig. 12, of average relative target strength.

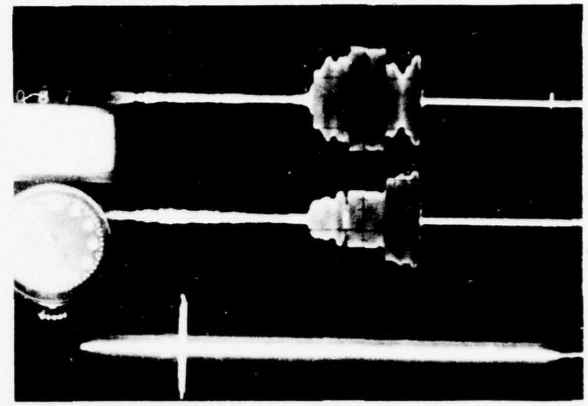
u
(X) Ordnance Research Laboratory (ORL), Pennsylvania State University, presented patterns of the angular dependence of target strength of the parent SKIPJACK (SSN 585) in their reports of submarine target strengths.* Two of their patterns obtained with a 30 msec transmission are reproduced as the solid curves of Figs. 13 and 14. The ORL frequency was 20.5 kHz. The target was at 55 ft depth, with the sonar at 30 ft depth. The solid curve of Fig. 13 shows the angular dependence of ORL's peak target strength measurements;

---

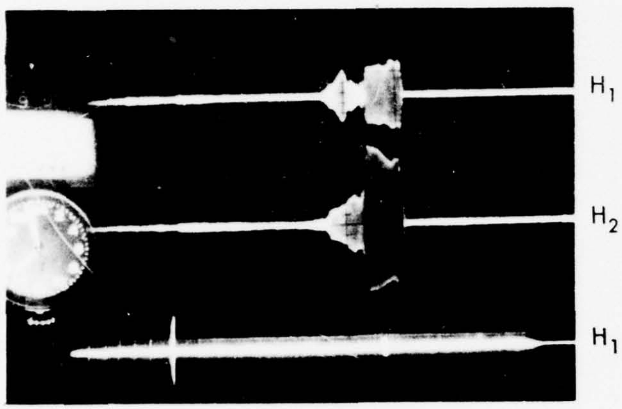
*W. J. Leiss, "Submarine Target Strength," (U), Parts I-X, Ordnance Research Laboratory, Pennsylvania State University, Technical Memorandums 204.4611-02 through 204.4611-11 (April - December 1964); Part IV; USS SKIPJACK (SSN 585). (CONFIDENTIAL)



(a) T = 5.45 msec SCALE: 2 msec/div; 20 msec/div

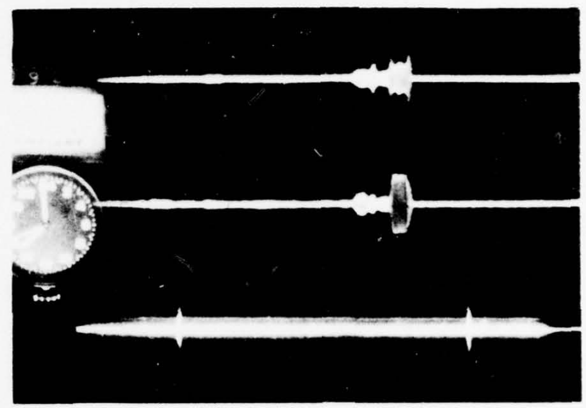


(b) T = 1.46 msec SCALE: 1 msec/div; 20 msec/div



(c) T = 0.73 msec SCALE: 1 msec/div; 20 msec/div

TIME



(d) T = 0.36 msec SCALE: 1 msec/div; 20 msec/div

FIGURE 6
ECHOES FROM SKIPJACK MODEL
TONE BURST SDT
f_0 = 240 kHz R = 410 ft B = 2.29 ft
ϕ = 090 deg

ARL - UT
AS-69-527
KJD - EJW
5 - 27 - 69

[redacted]

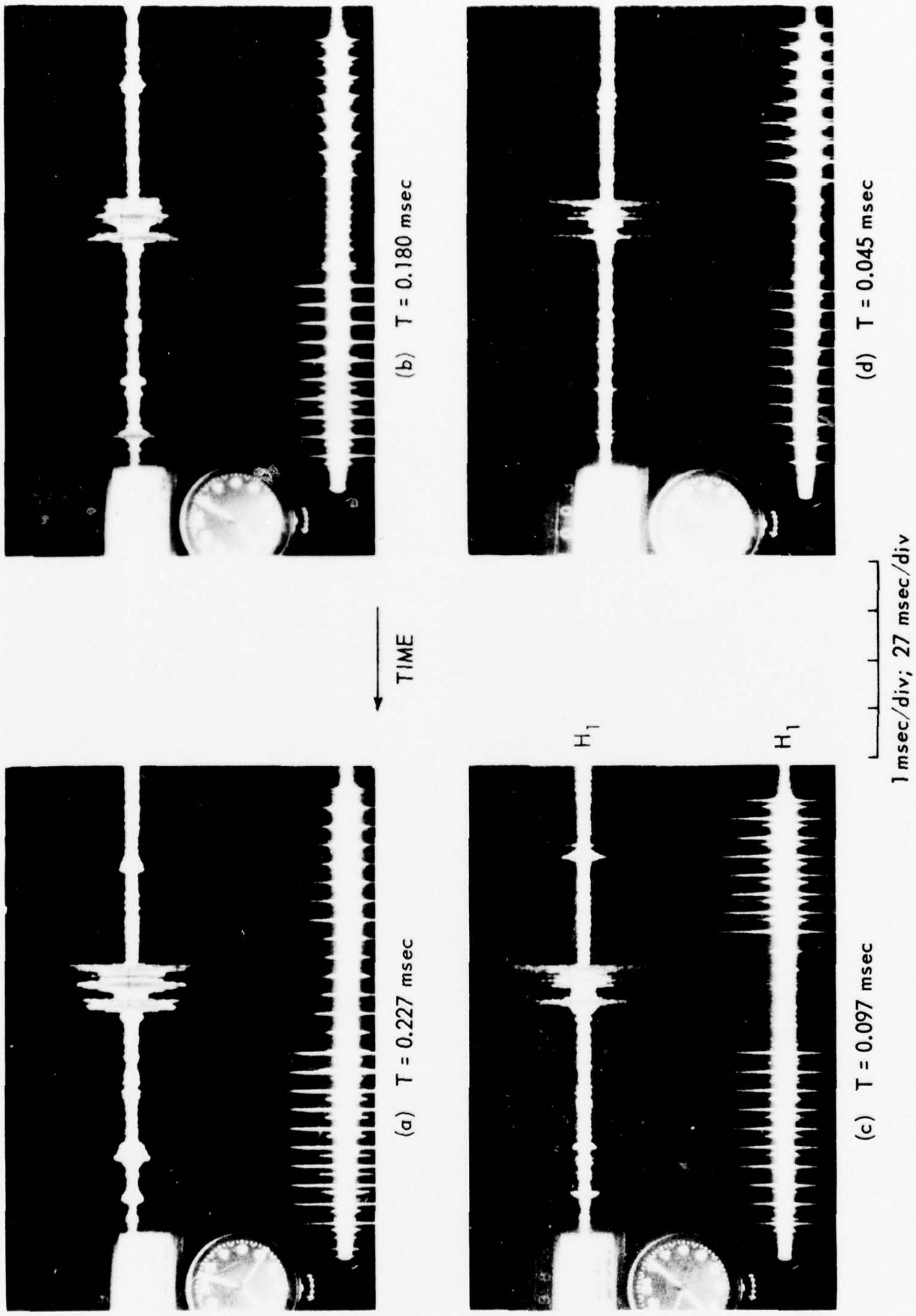


FIGURE 7
ECHOES FROM SKIPJACK MODEL
SIMULATED ASPECT
f_0 = 240 kHz R = 410 ft
ϕ = 090 deg

ARL - UT
AS-69-528
KJD - EJW
5 - 27 - 69

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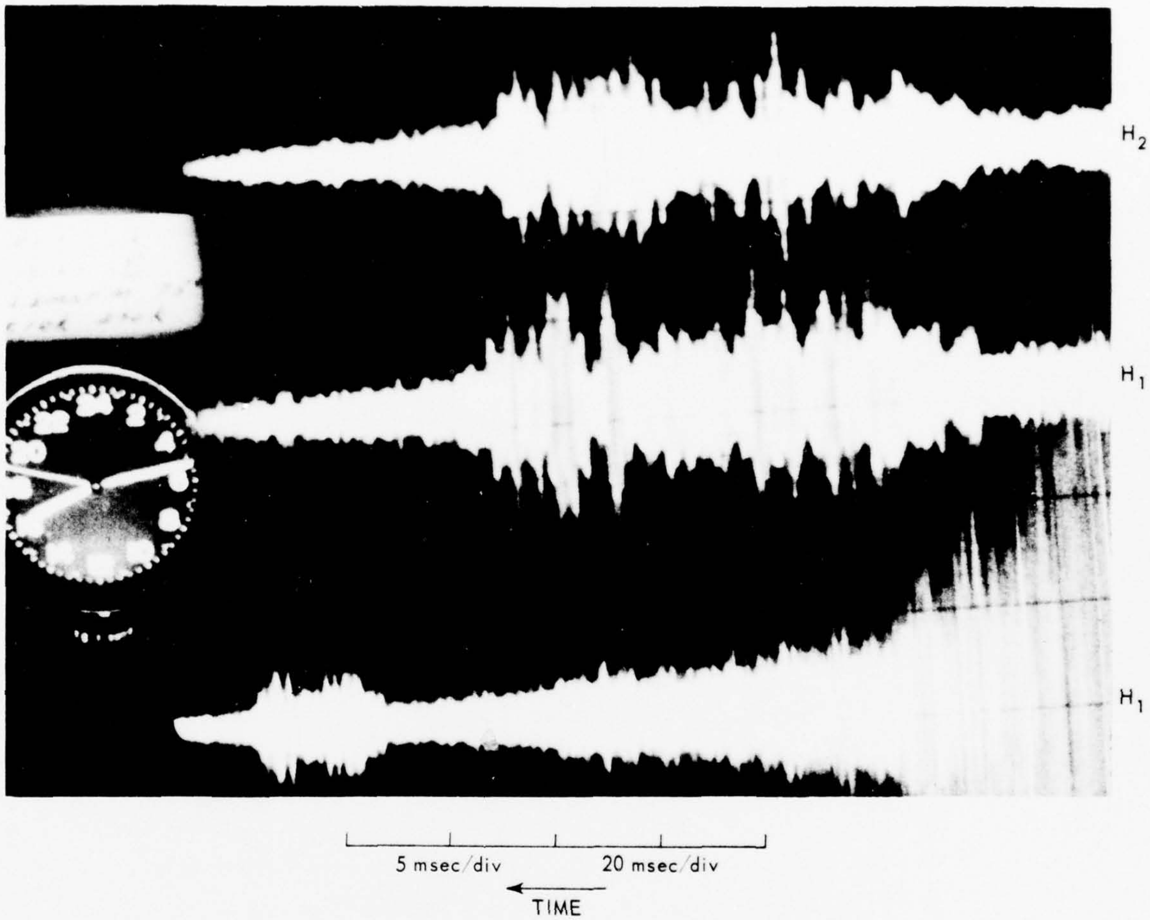
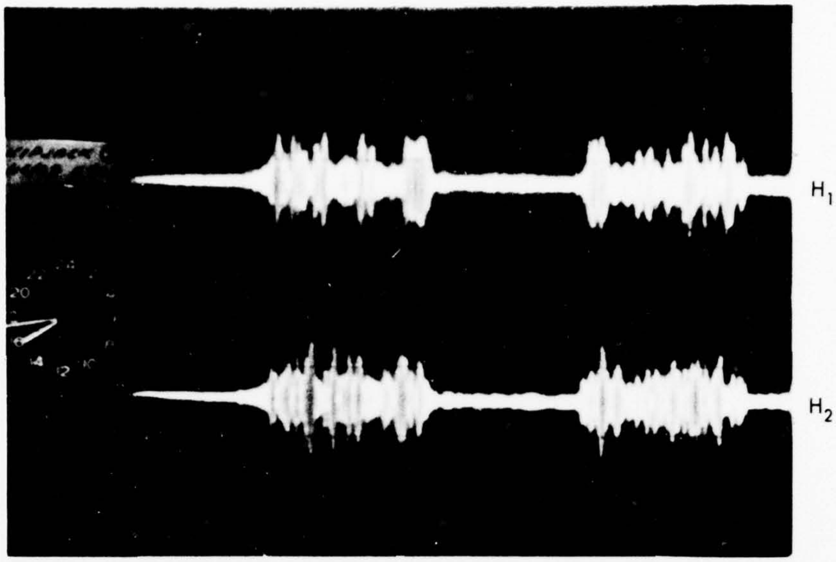
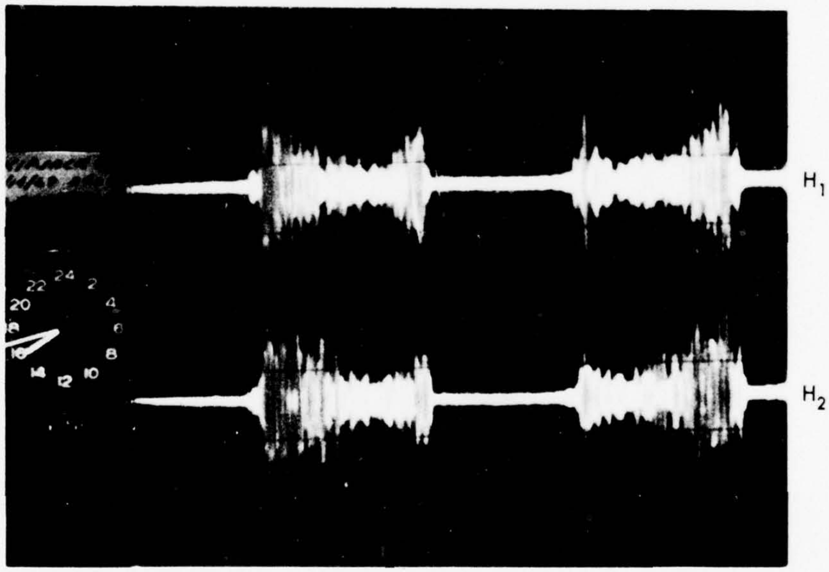


FIGURE 8
ECHOES FROM SKIPJACK MODEL
LFM TRANSMISSION
$T = 22.8$ msec $f_0 = 240$ kHz $W = 20$ kHz
$R = 410$ ft $B = 2.29$ ft
$\phi = 075$ deg

ARL - UT
AS-69-529
KJD - EJW
5 - 27 - 69



(a) ϕ = 105 deg



(b) ϕ = 035 deg

TIME

FIGURE 9
ECHOES FROM SKIPJACK MODEL
SPLIT HOUSETOP LFM TRANSMISSION
T = 22.8 msec f_0 = 240 kHz W = 20 kHz
R = 410 ft B = 2.29 ft
SCALE: 10 msec/div

ARL - UT
AS-69-530
KJD - EJW
5 - 27 - 69

[redacted]

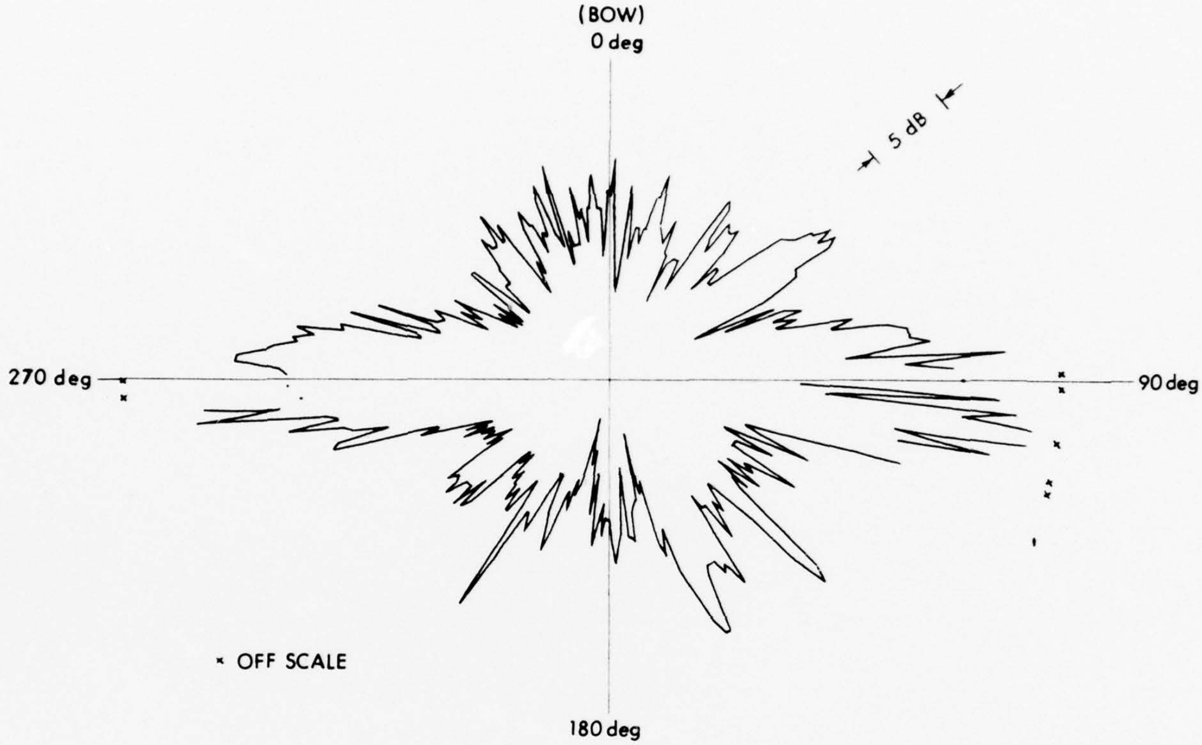


FIGURE 10
PEAK ECHO AMPLITUDE vs ASPECT
OF SKIPJACK MODEL
SCALED 2 msec TRANSMISSION
T = 0.091 msec f_o = 240 kHz R = 410 ft D = 22 ft
d_{SONAR} = 13.67 ft

ARL - UT
AS-69-544
KJD - ORS
6 - 9 - 69

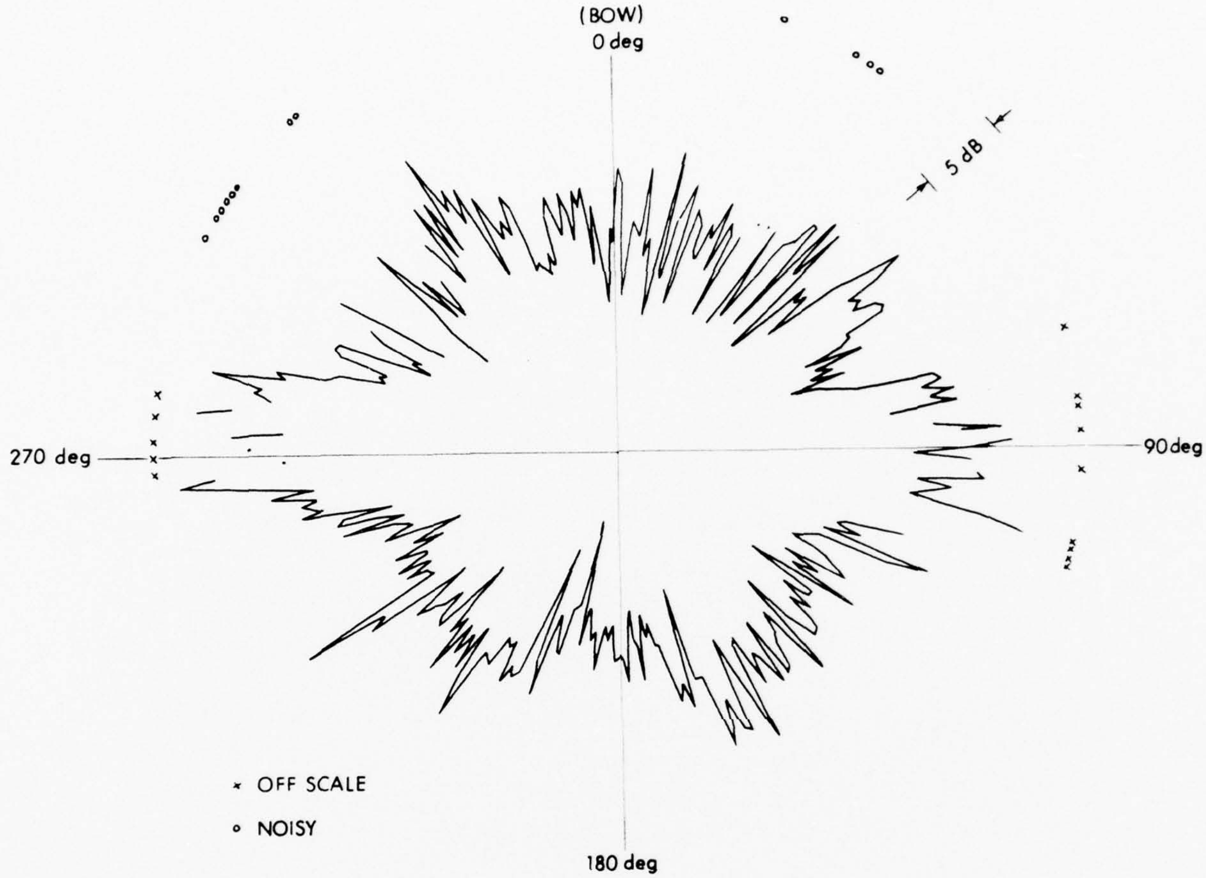


FIGURE 11
PEAK ECHO AMPLITUDE vs ASPECT
OF SKIPJACK MODEL
SCALED 30 msec TRANSMISSION
T = 1.46 msec f_o = 240 kHz R = 410 ft D = 22 ft
d_{SONAR} = 13.67 ft

ARL - UT
AS-69-545
KJD - ORS
6 - 9 - 69

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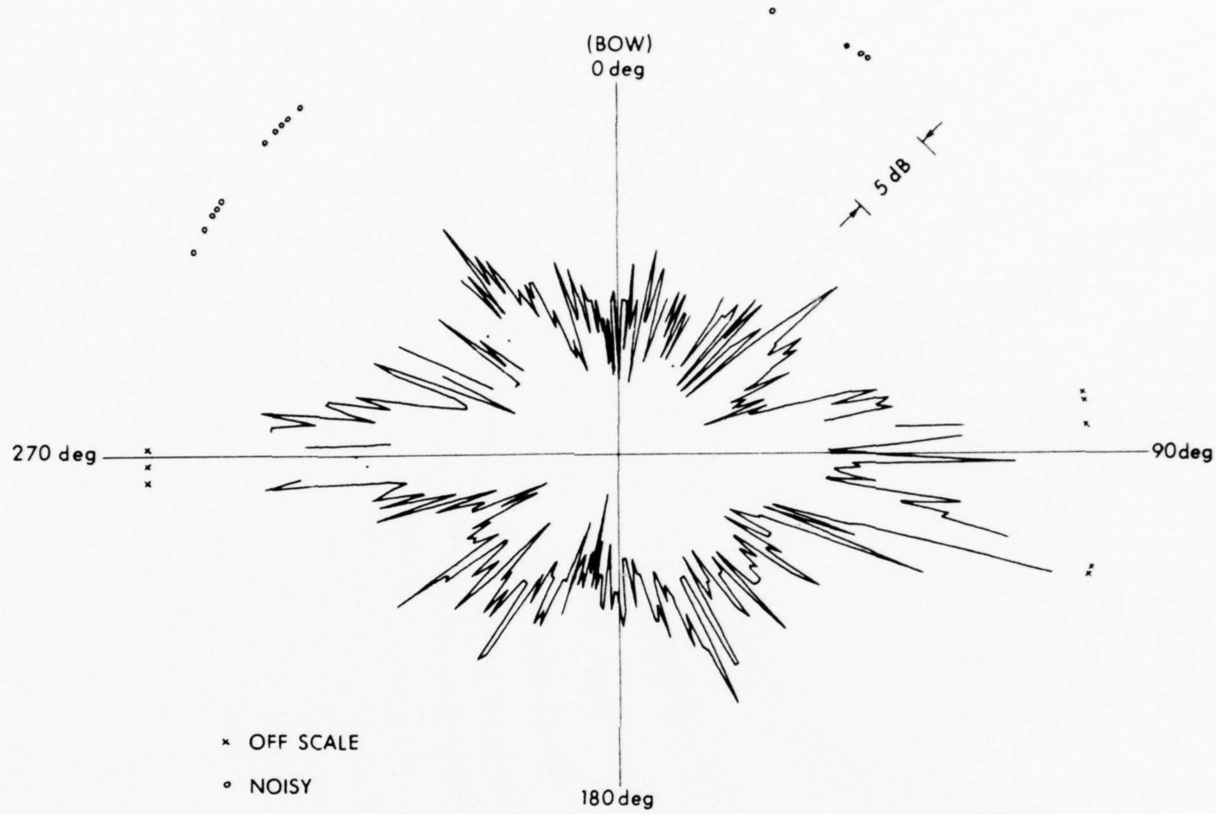


FIGURE 12
AVERAGE ECHO AMPLITUDE vs ASPECT
OF SKIPJACK MODEL
SCALED 30 msec TRANSMISSION
T = 1.46 msec f_o = 240 kHz R = 410 ft D = 22 ft
d_{SONAR} = 13.67 ft

ARL - UT
AS-69-546
KJD - ORS
6 - 10 - 69

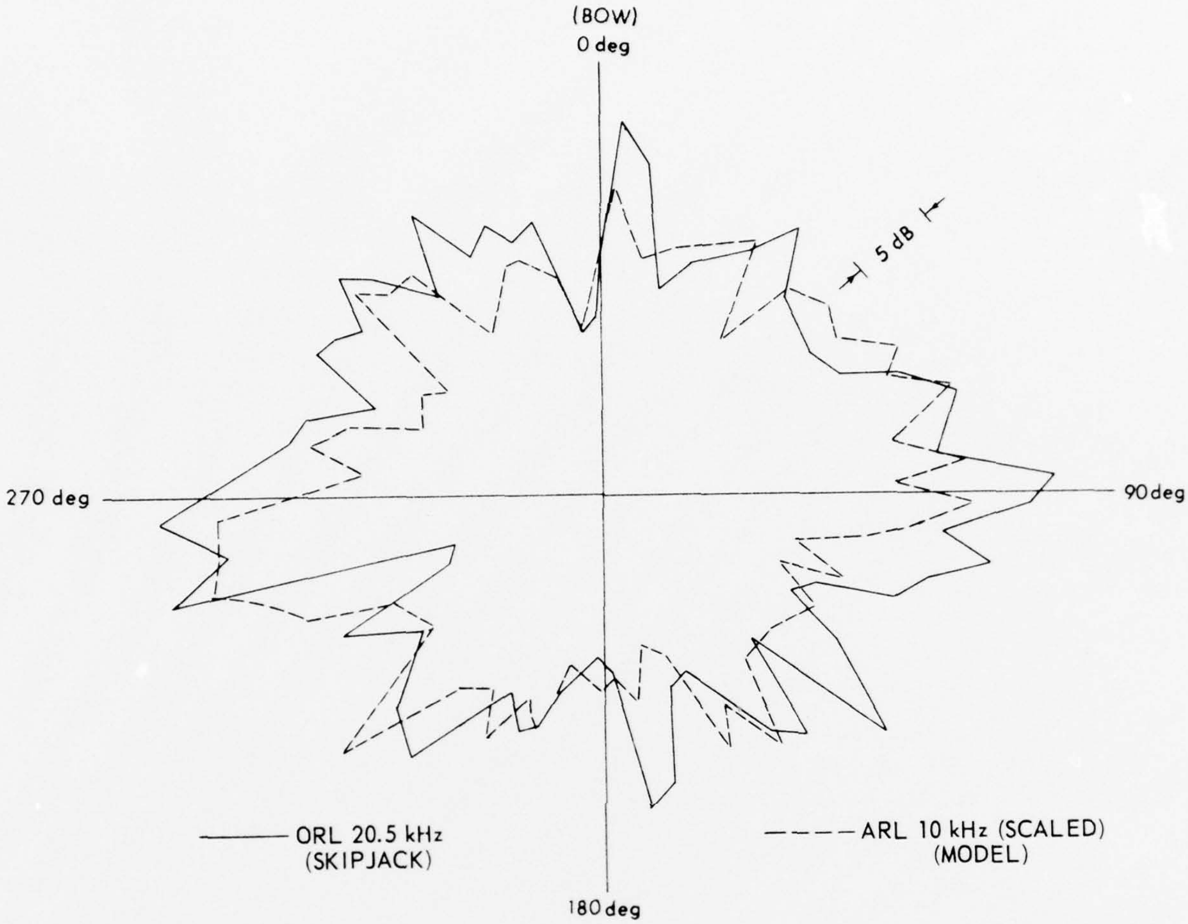


FIGURE 13
PEAK RELATIVE TARGET STRENGTH vs ASPECT
OF USS SKIPJACK (SSN585)
AND MODEL (U)
SCALED 30 msec TRANSMISSION

ARL - UT
AS-69-547
KJD - ORS
6 - 10 - 69

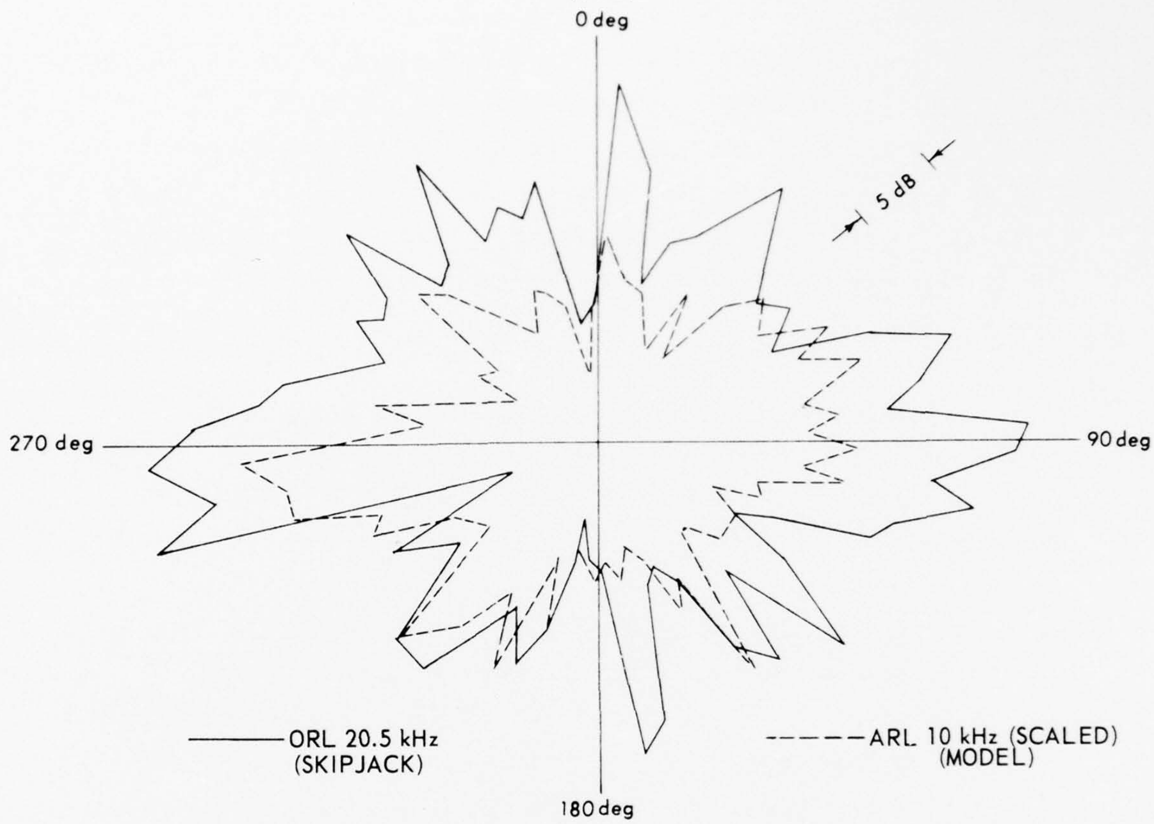


FIGURE 14
AVERAGE RELATIVE TARGET STRENGTH vs ASPECT
OF USS SKIPJACK (SSN585)
AND MODEL (U)
SCALED 30 msec TRANSMISSION

ARL - UT
AS-69-548
KJD - ORS
6 - 11 - 69

(U) Fig. 14, of their average target strength measurements. The ORL measurements were recorded at 3 to 10 deg aspect intervals and hence, show little of the fine structure of the ARL patterns (Figs. 11 and 12). To compare the model data with the ORL data an attempt was made to plot the model's relative target strengths at the <u>same</u> aspect values reported by ORL. These results are shown by the connected points of Figs. 13 and 14. It is evident that the angular dependence of the target strengths of the SKIPJACK (SSN 585) and the ARL model of it are similar.

(U) From the results compared in Figs. 13 and 14 it is concluded that the angular dependence of the scattering strength of the ARL model of the SKIPJACK is representative of full-scale measurements.

(U-~~FOUO~~) During the next quarter 3-sensor data at scaled 5 kHz will be collected for the SKIPJACK model and for such nonsubmarine targets as may be conceived and "successfully" modeled. An attempt will be made to implement the transmission sequences proposed for use in D/S 515 and to collect and analyze model data prior to the full-scale measurements. The measurements already performed at scaled 11 kHz and lost on account of recorder misalignment, will be repeated. Statistics of samples of the model data will be computed and compared with similar statistics of samples of sea data from the ARL tape library to arrive at a quantitative evaluation of the model data. Subsequently, a catalog of recorded model data will be issued.

B. Operations Analysis Section
(R. K. Goodnow)

1. Introduction

(U-~~FOUO)~~ During the report period the following work has been accomplished:

a. the DHDD report has been submitted to the Technical Reports Office for publication,

b. the ROGERS sea trip tapes have been reviewed for use in the construction of a new operator classification performance test,

c. preliminary feasibility study has been done for an expanded video B-scan presentation for the AN/SQS-23 sonar,

d. aid has been provided to the Electroacoustics Division for work determining the extent and pattern of intradome reflections in the AN/SQS-23 sonar dome,

e. the review of data photographs for the SME-to-PME dubbing quality verification program has been started,

f. a rough draft of the Operator Classification Aids Guideline report has been largely completed,

g. The Operator Classification Aids Testing program for estimating the classification contribution of HHIP, MITEC, MONOPPLER, and ASPECT has started,

h. The provision of data tapes to FASWS has been discontinued until further notice.

2. DHDD Report

(U-~~FOUO)~~ The final draft of the DHDD report was submitted to the Technical Reports Office on 20 January 1969; the final modifications of drawings and figures were completed during February. The report will be issued as ARL Technical Report No. 69-1 (ARL-TR-69-1),

(U-~~FOUO~~) entitled, "A Laboratory Investigation of the Raytheon Digital High Definition Display (DHDD)" (U), 22 January 1969, by Robert K. Goodnow. It is expected that this report will be released in April.

3. Review of USS ROGERS tapes

(U-~~FOUO~~) The data tapes recorded during the September-October 1968 sea trip on board the USS ROGERS (DD 876) have been reviewed for use as source material for construction of a new operator classification performance test. From this first examination it appears that new operator tests can be constructed for both sonar and ASPECT. The limiting factor for test construction is the number of nonsubmarine events in this data base.

(U-~~FOUO~~) It is expected that final examination of the selected events and assembly of the test will take place during the next quarter. The amount of time available in the Playback Facility for this work will be the factor that determines the completion date for test construction.

4. Video B-Scan

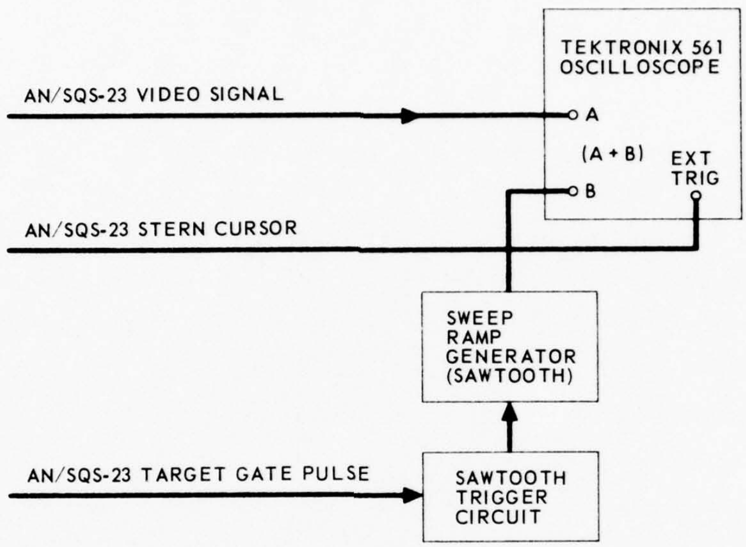
(U) A portion of the time during the quarter was devoted to conducting a feasibility study of an expanded display of the sonar video signals. By expanding a small portion of the video sweep spiral on an auxiliary display, greater range resolution of the scanned target echoes can be provided to the operator. Bearing resolution is still limited by the combination of scanner-beamwidth and scanning speed.

(U) This study was begun as a study of the sampling of the sonar echo by the video scanner, with a comparison made between the video scanner signals and the audio scanner signal. The audio scanner looks at echoes from a bearing continuously, while the video scanner samples echoes from a particular bearing every 6 2/3 msec. For the frequency

(U) of the sonar, this sampling rate is rather far below the rate established by Shannon, Nyquist *et al.*, as being necessary for extraction of all information from a signal, or for preservation of a signal. The idea behind the study was that the information of interest in the sonar signal is echo envelope amplitude, so that slow sampling by the video scanner might be adequate for preserving the envelope information. It was found that the video scanner sampling is not too bad, but that since no prediction can be made, *a priori*, of the echo envelope, faster sampling would be better.

(U) A laboratory oscilloscope was set up to give a B-scan presentation of the video signals, sweeping vertically as driven by an externally generated linear slow sawtooth voltage (triggered by the "target gate" pulse of the sonar). The video signals were added to the slow sawtooth to give horizontal scan lines showing vertical deflection generated by the video signals used to brighten the sonar PPI display. Horizontal sweep of the scope was triggered by the "ship's stern" cursor pulses of the sonar. A block diagram is given in Fig. 15.

(U) The major classification limitation of the sonar PPI display presently in use is the loss of range definition caused by overlap of the video scan lines on the face of the CRT. Overlap is as high as 98% for the 40,000 yd range scale, with a minimum of 38% for the lowest range scale, 1000 yd. This overlap causes blurring together of the range samples taken by the scanner, resulting in loss of range interval information on the display. This loss can be recovered by expanding a small part of the range sweep, as is done by the display used for the sampling study; this display removes the "display limiting" of the sonar PPI, and presents to the operator all of the range discrimination capability of the sonar. This type of display should be useful as a classification display.



NOTE:
AN/SQS-23 STERN IS USED TO TRIGGER FAST HORIZONTAL SWEEP. AN/SQS-23 TARGET GATE PULSE DRIVES SWEEP RAMP GENERATOR, GIVING SLOW SAWTOOTH THAT DRIVES VIDEO SIGNALS UP SCOPE FACE. SCOPE TIME CIRCUITS ARE USED TO SELECT "BEARING GATE" FOR DISPLAY.

FIGURE 15
BLOCK DIAGRAM, E–B–S (EXPANDED B-SCAN) DISPLAY

ARL - UT
AS-69-790
RKG - RFO
8 - 1 - 69

U (~~C~~) Several photographs of this display are given in Fig. 16. A display suitably combining the video B-scan and the audio A-scan will provide to an operator all of the information that this sonar can extract from a target echo without additional signal processing. It is planned to assemble a combined display later this year and test it for classification contribution.

5. Dome Reflection Study

(U-~~FOUO)~~ Mr. David A. Smith of the Electroacoustics Division of ARL was provided with tapes that show the effects of acoustic reflection within the AN/SQS-23 sonar dome. Mr. Smith is the originator of the Nearfield Bearing and Accuracy Calibration System (NEFBRACS) concept, and is concerned with the acoustic properties of the AN/SQS-23 sonar dome.

(U-~~FOUO)~~ Acoustic reflections are evident in several tapes that were recorded on board the USS SARSFIELD (DD 837), and can also be seen on some of the tapes from USS WITEK (DD 848) and USS ROGERS (DD 876). Tape loops were fabricated by dubbing ping sequences from several of the SARSFIELD tapes from the SME to the PME, then cutting out selected ping cycles and splicing these into loops. The loops were then run using the tape loop adapter that was fabricated for the Playback Facility last year. The transmission type selected for this study was ASPECT transmission, because of the multiple target echoes (and multiple dome reflections), making it easier to get reflection pattern measurements quickly. One of the measured reflection patterns is shown in Fig. 17. The direct target lobe is shown at the top of the page, with ship's head indicated by the arrow drawn to lower left. Relative bearing to the target is 120°. A major reflected lobe is shown about 5° to the left of ship's head; this is reflection from the forward portside curvature of the sonar dome. It can be seen from the plot that this reflection is only 9.5 dB below the main target lobe.

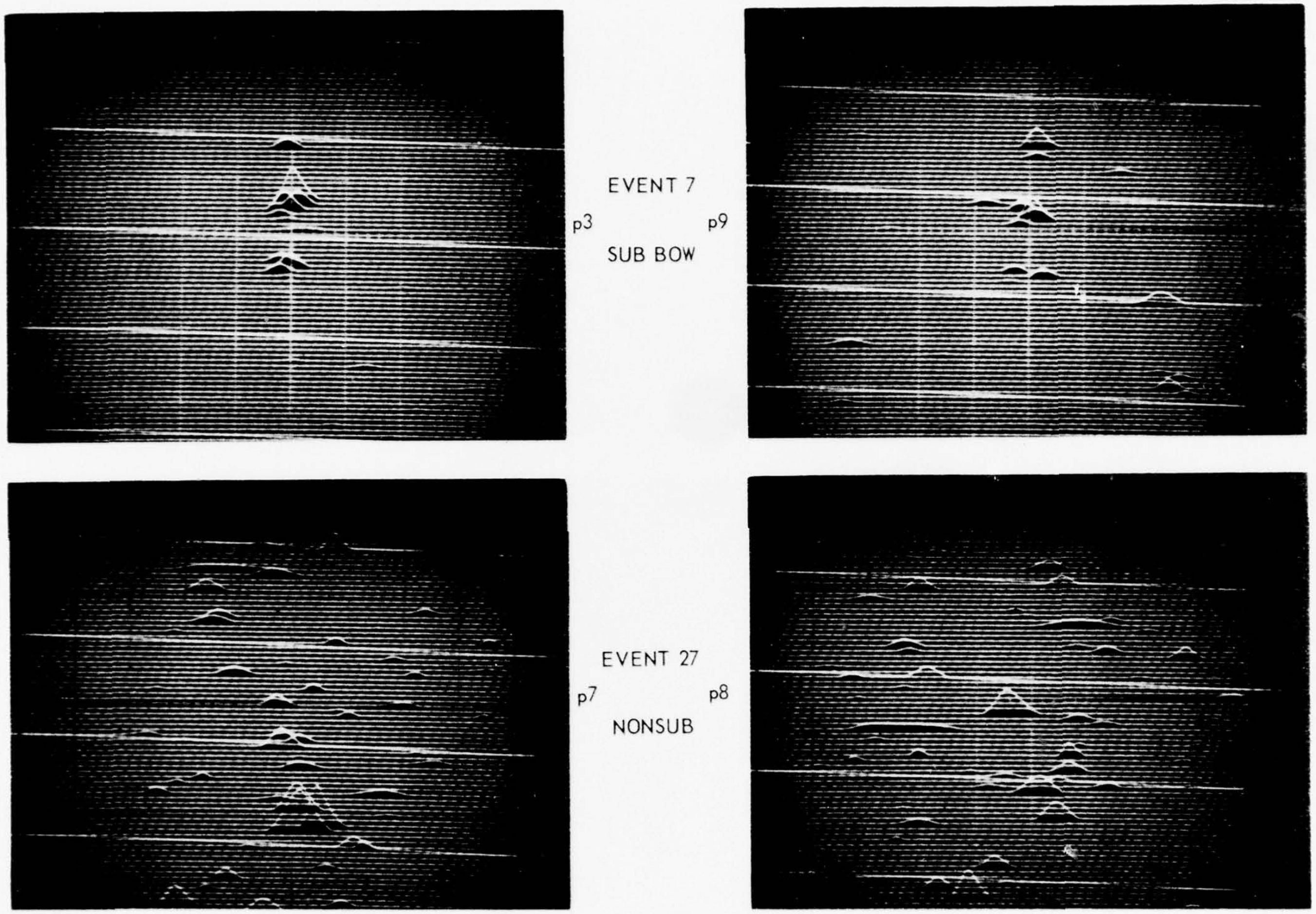


FIGURE 16
E–B–S DISPLAY UNMODIFIED
EVENTS 7, BOW ASPECT SUB, AND 27, NONSUB

ARL - UT
AS-69-791
RKG - RFO
8 - 1 - 69

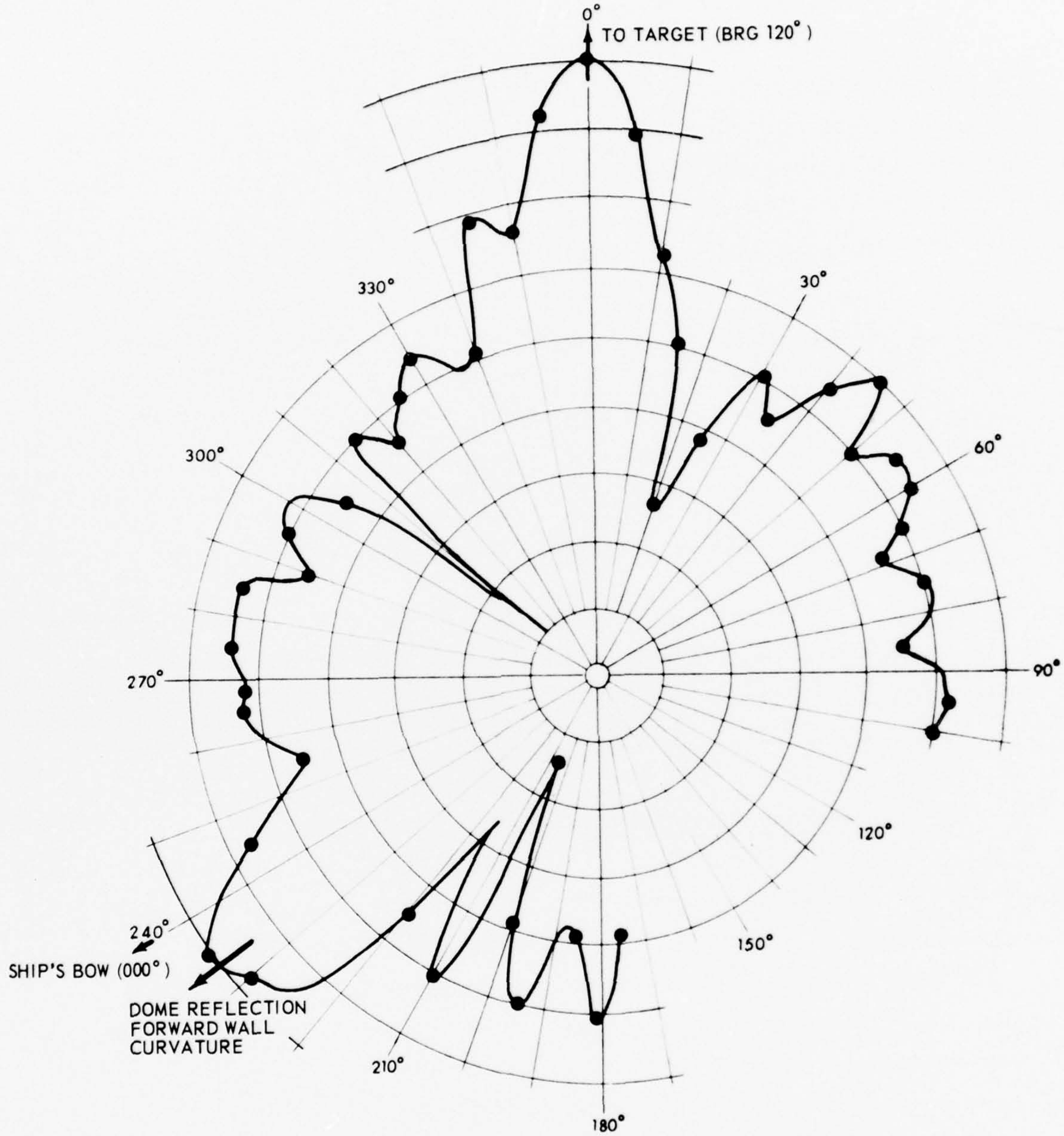


FIGURE 17
DOME REFLECTION BEAM PATTERN

ARL - UT
AS-69-792
RKG - ORS
8 - 5 - 69

[redacted]

(U-~~FOUO)~~ Other parts of the sonar dome also give rise to high level reflections, the baffle and the nearly flat sides being the next major reflectors. The target must be close to abeam of the ship for these reflections to be large, with a slightly forward of beam location giving rise to the strongest baffle reflections.

6. Dubbing Quality Verification

(U-~~FOUO)~~ Film viewers for use in the dubbing quality verification work have been procured. The procedure for this work has been established, and data sheets are being drawn up. This work will proceed on a low priority basis until completed.

7. Operator Classification Aids Guideline Report

(U-~~FOUO)~~ A rough draft of this report is largely completed, although much detail work remains to be done. It is hoped that this can be completed during April, and that the final draft can be submitted to the Technical Reports Office no later than 1 June 1969.

8. Operator Classification Aid Testing Program

(U-~~FOUO)~~ The testing program for estimating the classification contribution of several existing classification aids--HHIP, MITEC, MONOPPLER, and ASPECT--has commenced. Four new operators are being trained in the use of the AN/SQS-23. One subject has had extensive experience with several types of sonar, another has had several months experience on the AN/SQS-23, and the two remaining subjects are naive. The inexperienced subjects will be given rudimentary training in target classification, and all subjects will be given training in use of the rating scale used for announcing classification decisions.

(U-~~FOUO)~~ It is necessary to train new subjects because all of the subjects previously used have either left ARL or are busy on other projects. All new subjects will first be given the OCPT to establish their baseline classification performance. It is expected that this testing will commence early in April and the classification aid testing program will start soon thereafter.

9. <u>Provision of Data to Other Facilities</u>

(U-~~FOUO)~~ The provision of data tapes to Fleet ASW School, San Diego, has been discontinued until further notice. The majority of the ARL tapes were made with un-TRAMmed sonars, and FASWS concluded that the pre-TRAM 2 msec short pulse information was unsuitable for use in the generation of training tapes. It was felt that the amount of medium pulse length data on the tapes (roughly half) did not justify the cost and risk of shipping the data tapes to San Diego.

(U-~~FOUO)~~ The provision of data to Dunlap and Associates for their work in generating training programs for Fleet sonar operators has continued in 1969. Dunlap plans to visit ARL in April to test their new concept for target strength determination against the OCPT targets; the continued studies of these data have made their use in this project feasible. Results of this work will be reported shortly thereafter in a letter, and in the next Quarterly Progress Report.

C. <u>AN/SQS-23 Operator Detection Studies</u>
<u>(K. W. Harvel)</u>

(U-~~FOUO)~~ In cooperation with PMS-386, Naval Ship Systems Command, we have performed certain detection tests using the AN/SQS-23 Playback Facility at ARL. The following description presents the results obtained in our first attempt to measure operator capability with the AN/SQS-23.

U ~~(C)~~ The AN/SQS-23 sonar has been in the Fleet since 1958. A considerable amount of data has been gathered concerning its fleet use

(U) as a submarine sensor, and figure-of-merit (FOM) curves plotted against range have been published by Schulkin and Shaffer (Fig. 18 and Ref. 1). These FOM curves include sonar characteristics, environmental conditions and operator response. Quite obviously the detections the operator makes should be determined by the characteristics of the sonar and the environment as an upper limit on performance, and are reduced by less skill, training, and attentiveness to the detection task. To eliminate this human element as much as possible, operators are taught to make "altered" threshold judgments of synthetic targets. This threshold, called Minimum Detectable Level (MDL), has the advantage of eliminating operator variability due to skill, training, or attentiveness in searching for targets for the FOM calculations, but it has the distinct disadvantage of being so artificial a task that it may well not measure the true detection capability of the man-machine system. Indeed, several tests have shown that there is not a simple relationship between alerted and unalerted FOM as a function of range (Ref. 2). It follows from these data that one of the prime concerns with the operation of the AN/SQS-23 is the extremely large signal excess at short ranges needed for detection. The reason for this relative insensitivity is not clear. It may be hypothesized that:

1) the small size of echoes near the center of the scope is the cause--operators may not believe that anything that small could be a submarine;

2) the center of the scope is cluttered with bright background which effectively masks the target, which has similar size and brightness;

3) operators may never look in the center of the scope, feeling that targets should be detected farther out; and

4) operators may not adjust the receiver gain control through each ping, but leave it set for some "medium" range. This would preclude close-in detections because the variation in level is large over the range extent of the AN/SQS-23.

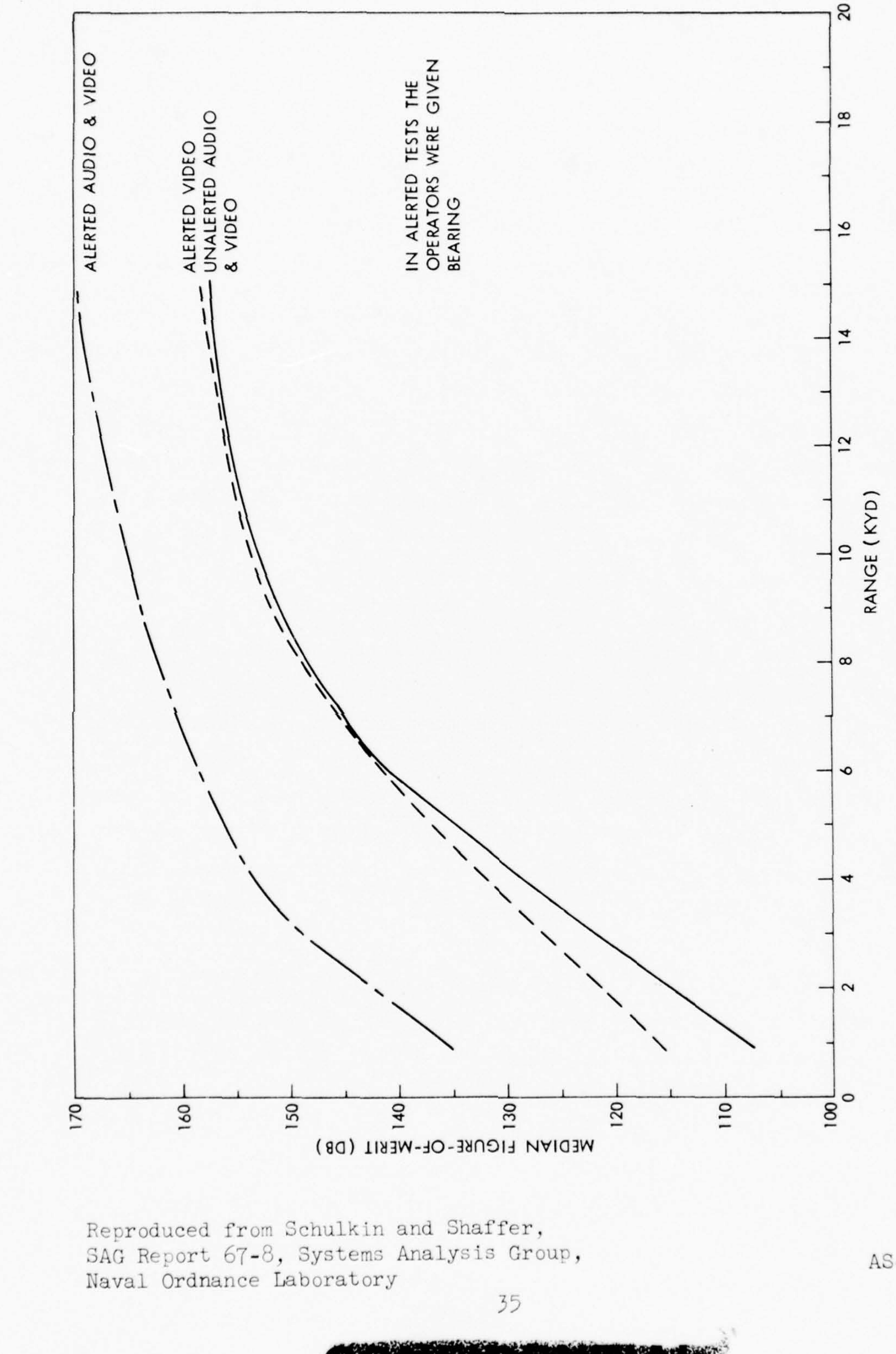


FIG. 2-2 AN/SQS-23 (XN-1) USS NORFOLK MEDIAN FIGURE-OF-MERIT (DB) VS RANGE (KYD) (15-KT, 20-KYD RANGE SCALE, SS2) (REF. (6)) (C)

FIGURE 18

Reproduced from Schulkin and Shaffer,
SAG Report 67-8, Systems Analysis Group,
Naval Ordnance Laboratory

AS-69-780

CONFIDENTIAL

(U-~~FOUO~~) The preliminary experiments reported here are an attempt to duplicate the results of the operational data in the laboratory under controlled conditions, to determine the causes for the at-sea results, and to recommend necessary changes in the AN/SQS-23 to remedy these deficiencies.

1. Procedure

(U-~~FOUO~~) By use of ARL's Playback Facility, a typical sonar operator's task may be recreated with the advantages of repeating the same situation for different subjects and of using different processing or display techniques. In accomplishing the limited study intended here, we were not completely able to simulate the detection task that confronts the operator aboard ship. The operator at sea is often in a convoy environment, or at least has a sonar display on which several surface ship contacts may appear. These contacts must be sorted through and compared with radar identifications to determine what contacts remain that might be submarine. After a check with radar, a detection may be called if the target is sufficiently submarine-like in appearance or sound; this action indicates that the sonarman feels that the target is apt to be a submarine and merits detailed attention. *An inaccurate comparison of radar and sonar ranges and bearings, or missed preliminary classifications, may result in false dismissals and are therefore listed as missed detections.*

(U-~~FOUO~~) These features of at-sea detection do not influence the tests given in the Playback Facility. In these detection tests we have assigned the operator the task of searching the display in both range and bearing until he locates an artificial target having the specific properties of the injected signal: a target that is 60 msec long, has the same amplitude on successive pings, and does not move in either range or bearing on successive pings. The operator thus knows the exact character of the target he is seeking. For our tests the operator's task is further simplified by allowing the operator to

(U-~~FOUO~~) familiarize himself with the background against which he is to detect targets; a test tape segment is selected and the operator views the segment repeatedly, becoming familiar with the task at hand. There is no indication that the operator improves his performance markedly during the test, however. Artificial targets were used to control signal-to-background ratio.

(U-~~FOUO~~) Signal-to-backbround is measured as $20 \log \frac{\text{rms signal}}{\text{rms noise}}$ at the output of the audio beamformer.

(U-~~FOUO~~) The background data for these tests were recorded off the California coast. The background contains a few real targets which are separable from the injected target by their apparent motion. Otherwise, the background is uniform out to a range of about 3800 yd, where the bottom reverberation begins to become the dominant background. Examples of the reverberation background are shown in Fig. 19 for three bearings. The initial power level is approximately equal for each of the relative bearings, but in the region of bottom reverberation the power level is highly variable. Note that the reverberation has different levels at different bearings. No bearing normalization of any type is provided in the system, and therefore the operator must choose either to turn down the gain manually so that targets in highly reverberant regions may be identified or to turn up the gain to search for targets in low reverberation areas. (For the 5 kyd test the operators were asked to not make adjustments to the gain of the system more than twice during a 20-ping segment.) The last trace on Fig. 19 is the fourth of the sequence of traces shown in Fig. 20. The strong return near the end of the trace appears as a target here (though it is somewhat too wide to be a target), but on the PPI it is clearly identifiable as a part of an extended ridge of reverberation.

(U-~~FOUO~~) Video-only detection tests were given to the operators; it was felt that the primary task of the operator is a video task, and

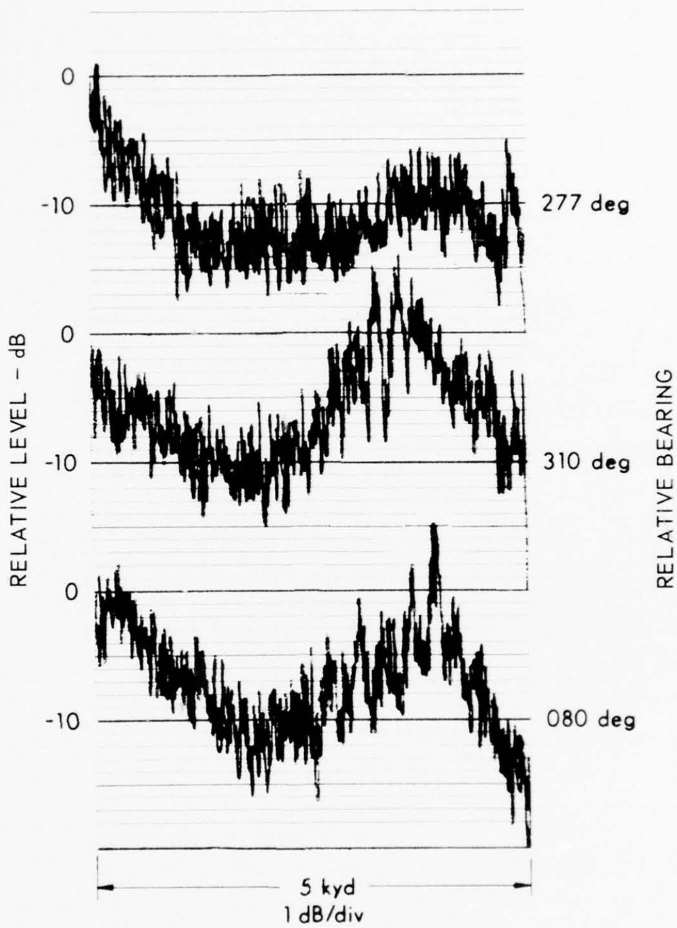


FIGURE 19
REVERBERATION FOR PPI 5 kyd DETECTION TEST
FM TRANSMISSION: 30 msec RDT
440 Hz, 36.4 msec SLIDE TAPE No. 57 ft 1761

ARL - UT
AS-69-380
KWH - RFO
4 - 11 - 69

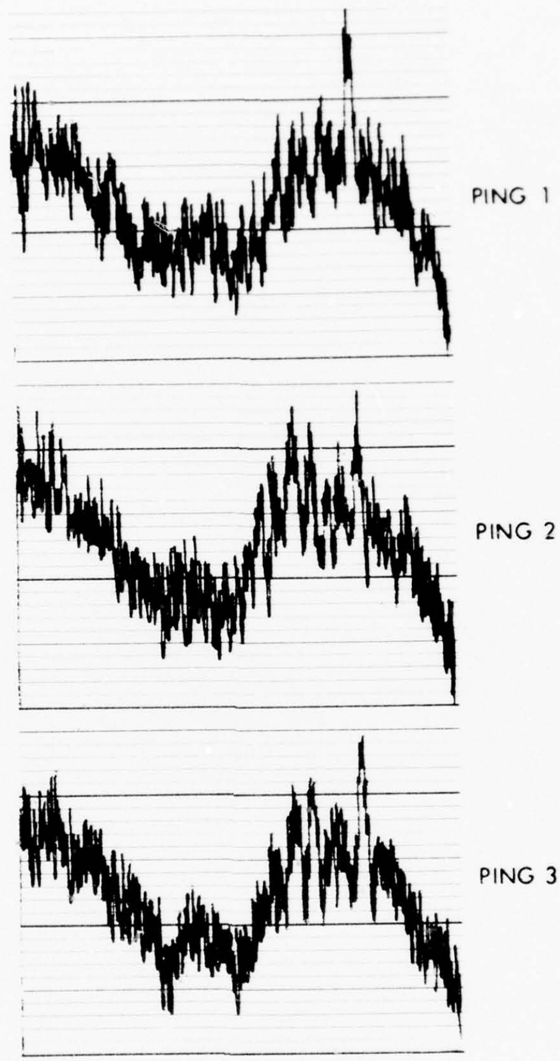


FIGURE 20
REVERBERATION REPEATABILITY
FOR PPI 5 kyd DETECTION TEST
BEARING 080 deg

ARL - UT
AS-69-381
KWH - RFO
4 - 11 - 69

UNCLASSIFIED

(U-~~FOUO~~) also that the coherent audio character of the artificially injected target would readily offer aid to a listener trying to decide that a suspect target was an actual artificial target. Artificial targets were injected about 30% of the time; the subject spent much of his time searching the display without results.

(U-~~FOUO~~) Subjects taking such tests in the laboratory are alert and motivated. Their comments indicate that they do not feel that it would be possible for them to improve their performance. On each ping a typical subject may mark on the display the location of 3 or 4 suspected targets by placing a finger over the suspect area, then on the next ping pay some extra attention to the marked location, plus selecting others to mark. In this manner a subject is operating with perhaps four "false alarms" per ping, but by placing the additional (but artificial) requirement that the target appear at <u>exactly</u> the same location on successive pings, the subject is able to reduce the false alarms to nearly zero before calling the target. Subjects reported that they usually saw the target on three successive pings before reporting it. (This was necessary to eliminate false alarms.)

2. <u>Operating Procedure</u>

(U-~~FOUO~~) All subjects in these tests were familiar with the operation of the AN/SQS-23 from prior tests. They knew that either one or no targets were presented on a given test segment. No instructions were given with regard to false alarms; however, most subjects reported few or none. When a subject called a false alarm the test continued; when he called a target, it was terminated.

(U-~~FOUO~~) Table I gives a composite picture of the tests which were run. Tests 2 and 3 were identical except that the displays were different and different operators were used. Each subject completed Test 1 in one sitting--about 2 1/2 h. Tests 2 and 3 were longer and subjects usually took these in two parts. All subjects reported

[redacted]

TABLE I

Test (Range Scale)	Display	Transmission Signal Type	No. of Targets	Segments	Search Sector	No. of Operators
1 5 kyd	PPI	FM	16	34	180 deg	6
2 20 kyd	PPI	cw	7	16	300 deg	3
3 20 kyd	B-scan	cw	7	16	300 deg	3
4 5/20 kyd	4 B-scan	cw	10 B-scan 5 PPI	Aborted	300 deg	1
5 20 kyd	PPI (PBR)	cw	15	Aborted	300 deg	1

(U-[redacted]) fatigue after about fifteen minutes of testing. This was important, since it was desired to see if watch length influenced detection. No deterioration in detection capability with fatigue was noticed; motivation remained high.

3. Results and Discussion

a. Test 1

(U) The first test was given on the 5 kyd range scale on the AN/SQS-23 PPI display, with the search area restricted to the forward 180 deg sector--the smallest area searched for any of these tests. A 20-ping segment of tape with a relatively stable reverberation pattern was first selected for the test. The sixteen items were divided so that there was a uniform distribution of targets with range, with the order and the bearing of presentation of the signals randomized. (This choice yields a nonuniform density of targets on the PPI display, and a uniform density on a B-scan.) The 20-ping segment of tape was played over 34 times during each operator test. On any particular play-through there was a 47% chance that a target would be present. (The actual pattern of target injection was selected as follows: TTO OTT 000 OOT OTT OTT TOO 000 OTT TTT 000 T, "T" indicating that a target was to be present on the segment and "O" indicating otherwise.) Figure 21 shows the location and sequence of these targets. When the target was to be added to the recorded background on a particular pass of tape, the target was initially inserted sometime during the first 10 pings. Once inserted, the target was maintained at that exact location and increased in level by 3 dB every 5 pings until the end of the 20-ping tape segment. At the beginning of the test, targets were inserted at a signal-to-reverberation level of 11 dB, but it was found during the test that several targets would go undetected before the sequence was completed; so these targets were started at the higher level of 14 dB so that levels as high as 20 dB S/B could be reached. The number of times

[redacted]

(This page is UNCLASSIFIED.) [redacted]

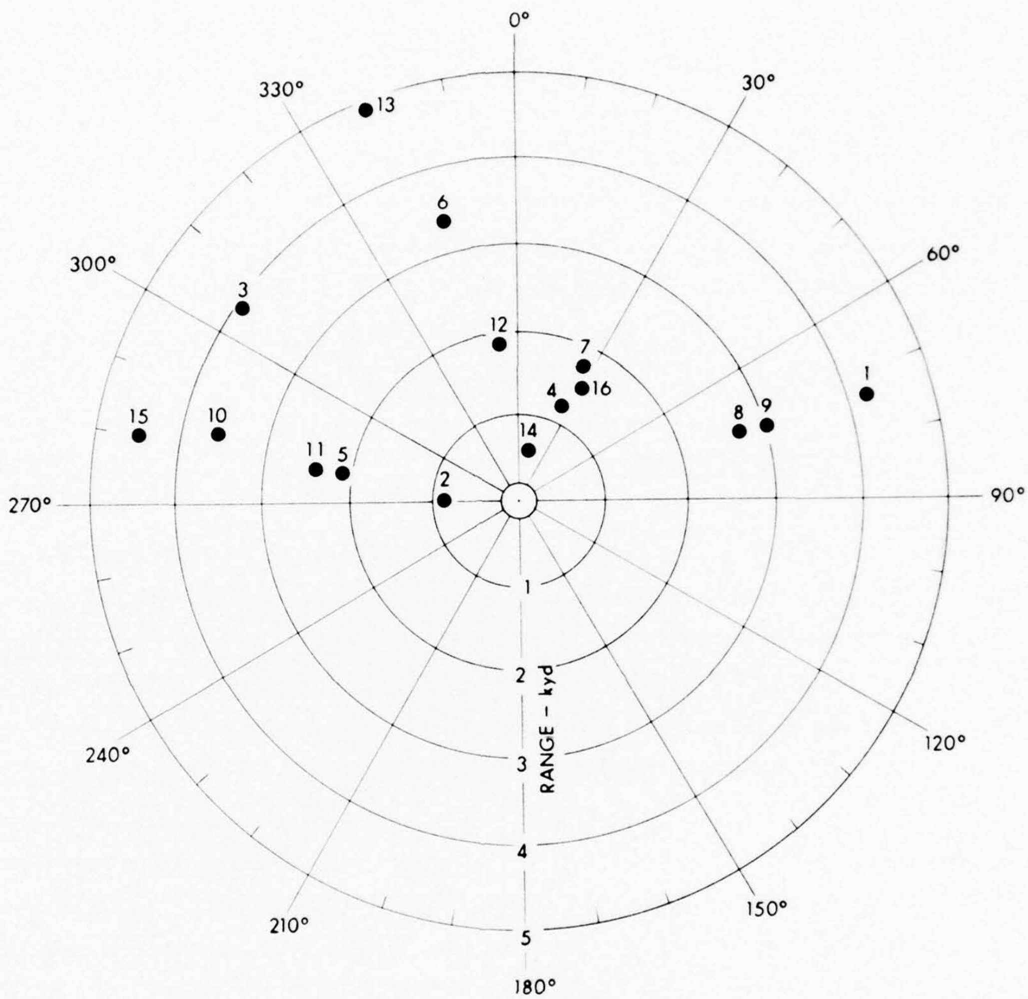


FIGURE 21
LOCATION AND SEQUENCE OF TARGETS
FOR PPI 5 kyd DETECTION TEST
180 deg SEARCH SECTOR

ARL - UT
AS-69-378
KWH - RFO
4 - 11 - 69

[redacted]

(U) the target was missed at each of the signal-to-background ratios was recorded for each of the operators.

(U) The results of this first test are summarized in Fig. 22 by showing the average for six operators of the signal level at which each of the targets was first called. The numbers shown in parentheses indicate the number of operators who missed the signal. The target at bearing 280°, range 2100 yd was frequently missed due to its proximity to a real target; the target at 346° was near an area of intense reverberation. Of the 16 targets missed (17%), one was missed at 20 dB S/B, 10 at 17 dB, 5 at 14 dB.

b. Tests 2 and 3

(U-~~FOUO~~) The second test required the operator to find targets on a 20 kyd PPI display, searching in a 300° sector. The sector the operator had to scan covered 6 2/3 times the water area of the previous test. The operator's performance was not seriously degraded, however, as can be seen in Fig. 23. Seven targets were given, and only three operators took the test. The test was similar to the previous (5 kyd) detection test, the only difference being that the operator was free to manipulate the gain control as he chose. AGC was not used and the operator essentially provided his own AGC with the manual control. The order of presentation of the targets, by bearing, was as follows: 218°, 278°, 113°, 019°, 061°, 265°, and 099°. The sequence of 20-ping segments on which targets were present is as follows: TOO OTT OOO TOO TOT T.

(U) Background for the test is shown at two bearings in Figs. 24 and 25 for the same ping. The target as shown in Fig. 24 was measured as 17 dB S/B; the three operators detected the target at an average of 16 dB. The target shown in Fig. 25 has a 20 dB S/B ratio, while this target was detected with an average 15 dB ratio.

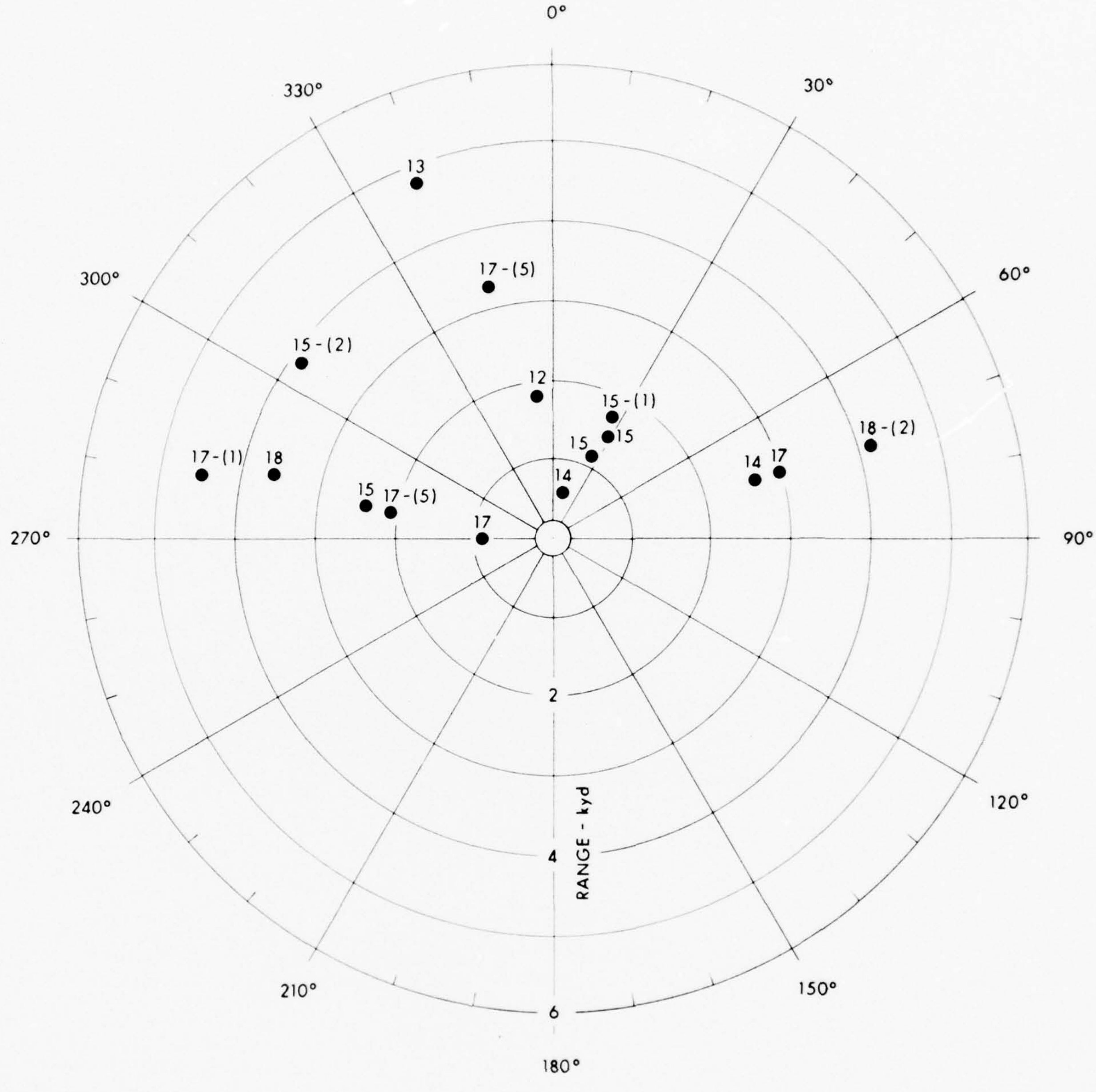


FIGURE 22
PPI VIDEO DETECTION FOR 5 kyd RANGE SCALE (U)
180 deg SEARCH SECTOR
6 OPERATOR AVERAGE

ARL - UT
AS-69-379
KWH - RFO
4 - 11 - 69

[redacted]

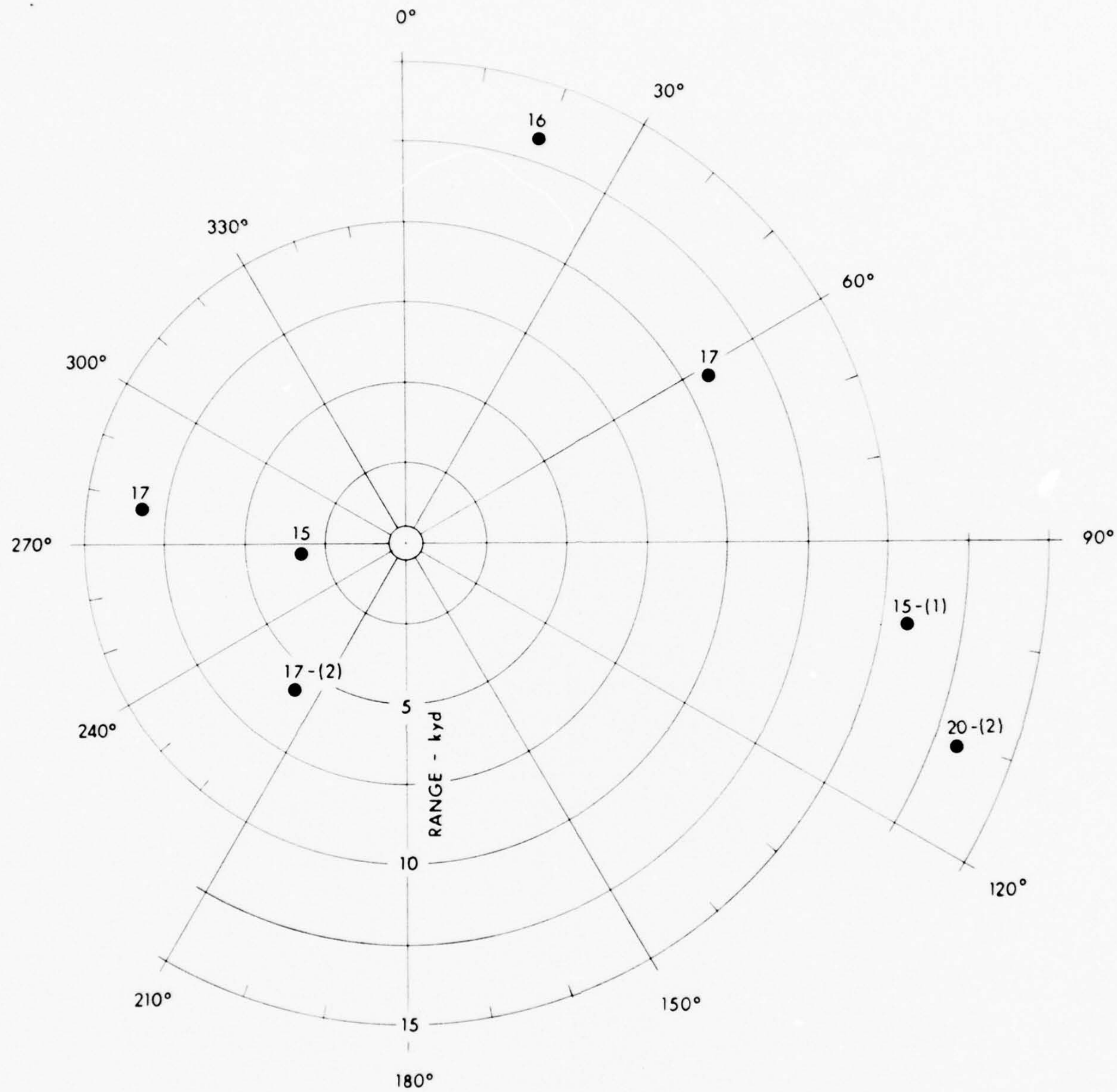


FIGURE 23
PPI VIDEO DETECTION FOR 20 kyd RANGE SCALE (U)
300 deg SEARCH SECTOR
3 OPERATOR AVERAGE

ARL - UT
AS-69-382
KWH - RFO
4 - 11 - 69

[redacted]

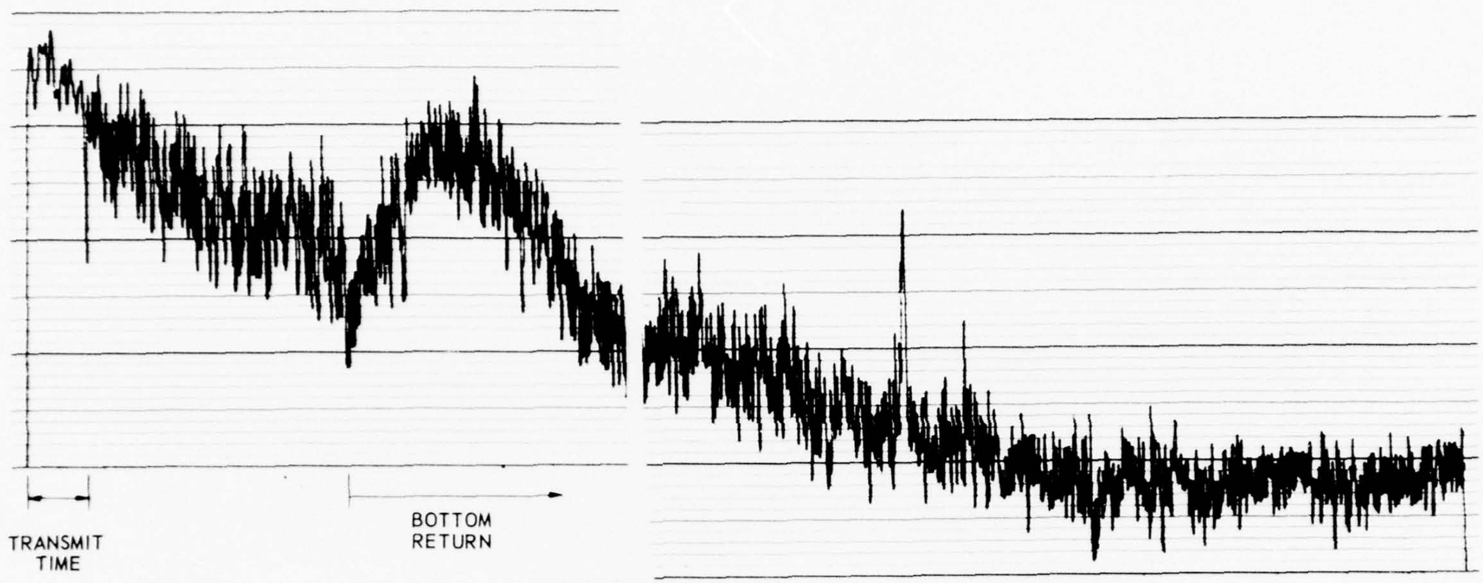


FIGURE 24
REVERBERATION FOR 20 kyd DETECTION TEST
WITH INJECTED 17 dB TARGET
AN/SQS-23 MEDIUM PULSE TRANSMISSION: 30 msec RDT
TARGET: 17 dB SIGNAL-TO-BACKGROUND, 019 deg, 12.5 kyd
TAPE No. 57 ft 0010

ARL - UT
AS-69-383
KWH - RFO
4 - 14 - 69

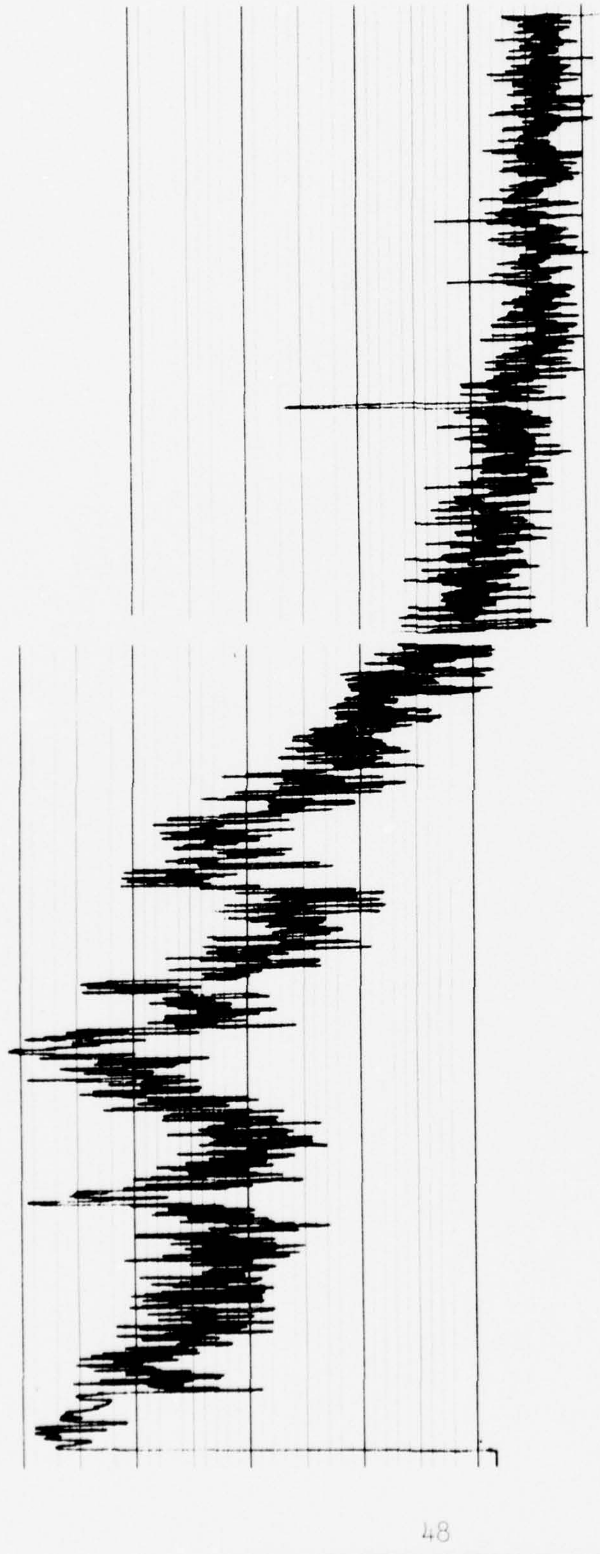


FIGURE 25
REVERBERATION FOR 20 kyd DETECTION TEST
WITH INJECTED 20 dB TARGET
TARGET: 20 dB SIGNAL-TO-BACKGROUND, 099 *deg*, 15 *kyd*

ARL - UT
AS - 69 - 384
KWH - RFO
4 - 14 - 69

[redacted]

U (~~C~~) Note that the reverberation patterns on Figs. 24 and 25 are markedly different, creating a significant gain adjustment problem on the display.

(U-~~FOUO~~) The same seven targets were given to another group of three operators on a B-scan display, and the average detection signal-to-background ratio is shown in Fig. 26. The B-scan was presented on a Tektronix oscilloscope with a 10 cm by 8 cm display and a p-7 phosphor. Very similar detection performance resulted. Results for the first three tests are summarized in Table II.

c. Test 4

U (~~C~~) Test 4 consisted of presenting one operator 4 pings on a 5 kyd B scope, then 1 ping on a 20 kyd PPI, a technique which aimed at providing the operator with less clutter close in and approximately the same data rate for near and far targets. The task seriously degraded detection on the 20 kyd PPI. One operator took the test and obtained a performance of 16.2 dB for detection S/B for the 5 kyd display on 10 targets, while missing 3 out of 5 targets on the 20 kyd single ping display. These targets were missed with 23 dB S/B. Two targets were found, one at 17 dB and the other at 23 dB. Other operators taking the test, with increasing signal-to-background, were usually able to find the targets at 29 dB S/B. Because this performance was so much poorer than the results shown in Tests 1, 2, and 3, this test was not continued.

d. Test 5

(U-~~FOUO~~) An operator detection test using the Preformed Beam Receiver (PBR), removed from the AN/SQS-23B sonars, was also attempted briefly. However, it was not, in general, possible to detect targets with this equipment, due to its limited output dynamic range, and the test was discontinued until such time as the receiver can be improved.

(U)

TABLE II

	5 kyd PPI	20 kyd PPI	20 kyd B-scan
Average S/B	15.3 dB	16.4 dB	15.9 dB
Total Missed	16	5	3
Percent Missed	17%	24%	13%

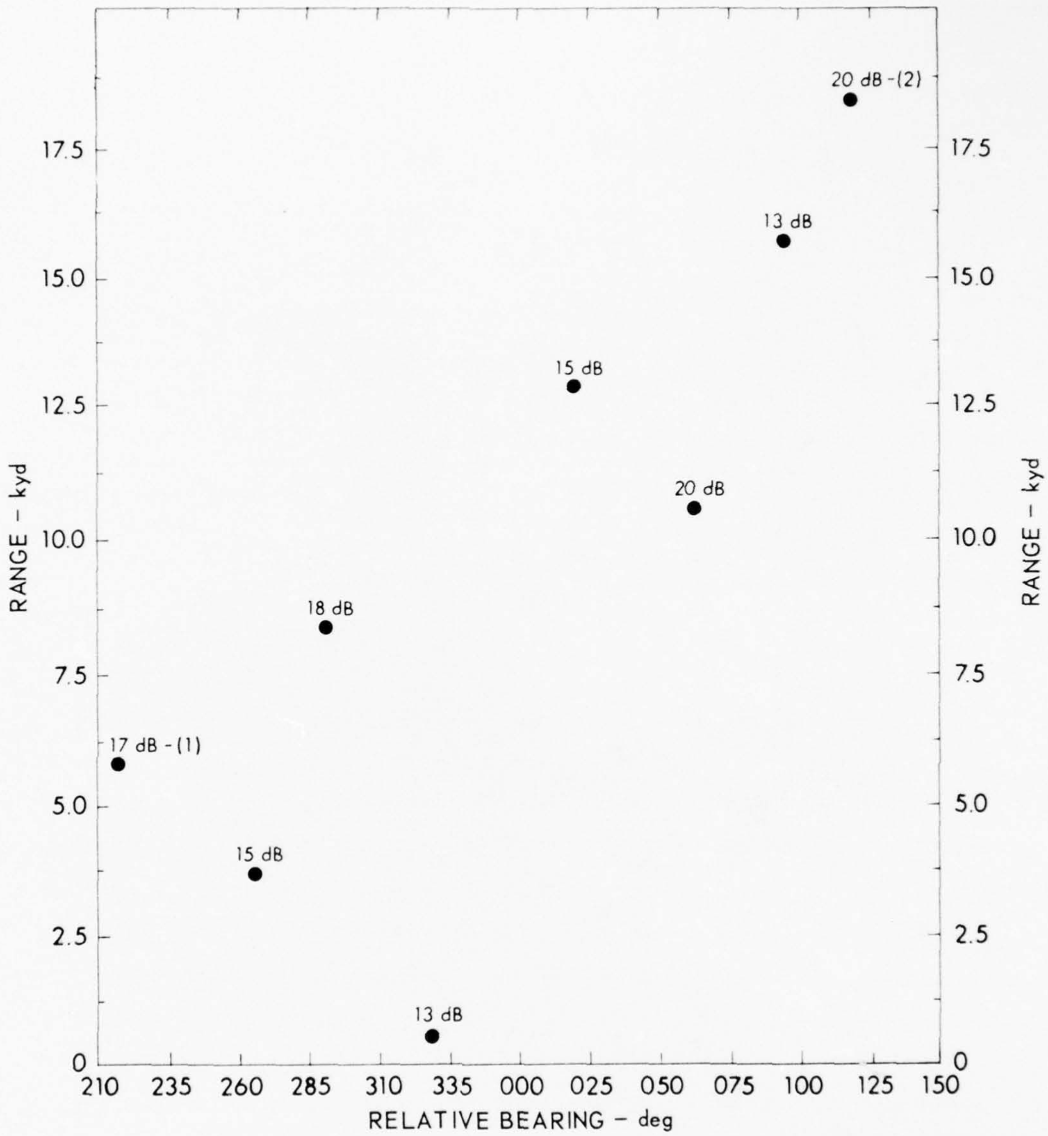


FIGURE 26
B-SCAN VIDEO DETECTION TEST (U)
20 kyd RANGE SCALE 300 deg SEARCH SECTOR
3 OPERATOR AVERAGE

ARL - UT
AS-69-385
KWH - RFO
4 - 14 - 69

(U-~~FOUO~~) The inherent capability of being able to normalize the background on the basis of bearing makes a PBR very attractive for performance improvement. Another desirable feature is the ease of using a history display and/or computer aided detection.

4. Summary

(U) It is interesting to compare this operator detection performance with the performance obtainable from a power averager in an ideal background. For the 5 kyd detection test, if it is assumed that the operator was making four false alarms per ping, the false alarm rate is 0.64 false alarms per second. Eighteen independent beams are assumed for the forward 180 deg sector and the rate becomes 0.036 false alarms per second per beam. With the 400 Hz FM slide used, and with the 60 msec target injected, the time-bandwidth (TW) product of the ideal averager can be 24. From Fig. 27, reproduced from Ref. 3, an output signal-to-background ratio of 6 dB yields the appropriate false alarm rate; and from Fig. 28, reproduced from Ref. 4, this indicates an input signal-to-background ratio of -3 dB at the output of a beamformer. Thus, an operator under the most alert conditions is operating 19 dB poorer with the AN/SQS-23 than an ideal square law detector-averager, followed by a threshold detector, in an ideal background. The background is not an ideal one, but a very important question is: how well would a suitably normalized detector work in an actual AN/SQS-23 reverberation background? It would appear from the signals shown in Figs. 24 and 25 that the present receive system could be significantly improved.

(U) It is also interesting to compare these measures of detection performance with those obtained by others who used at-sea performance data (Ref. 2). H. E. Fridge indicates that the differences in unalerted and alerted signal differentials are variable

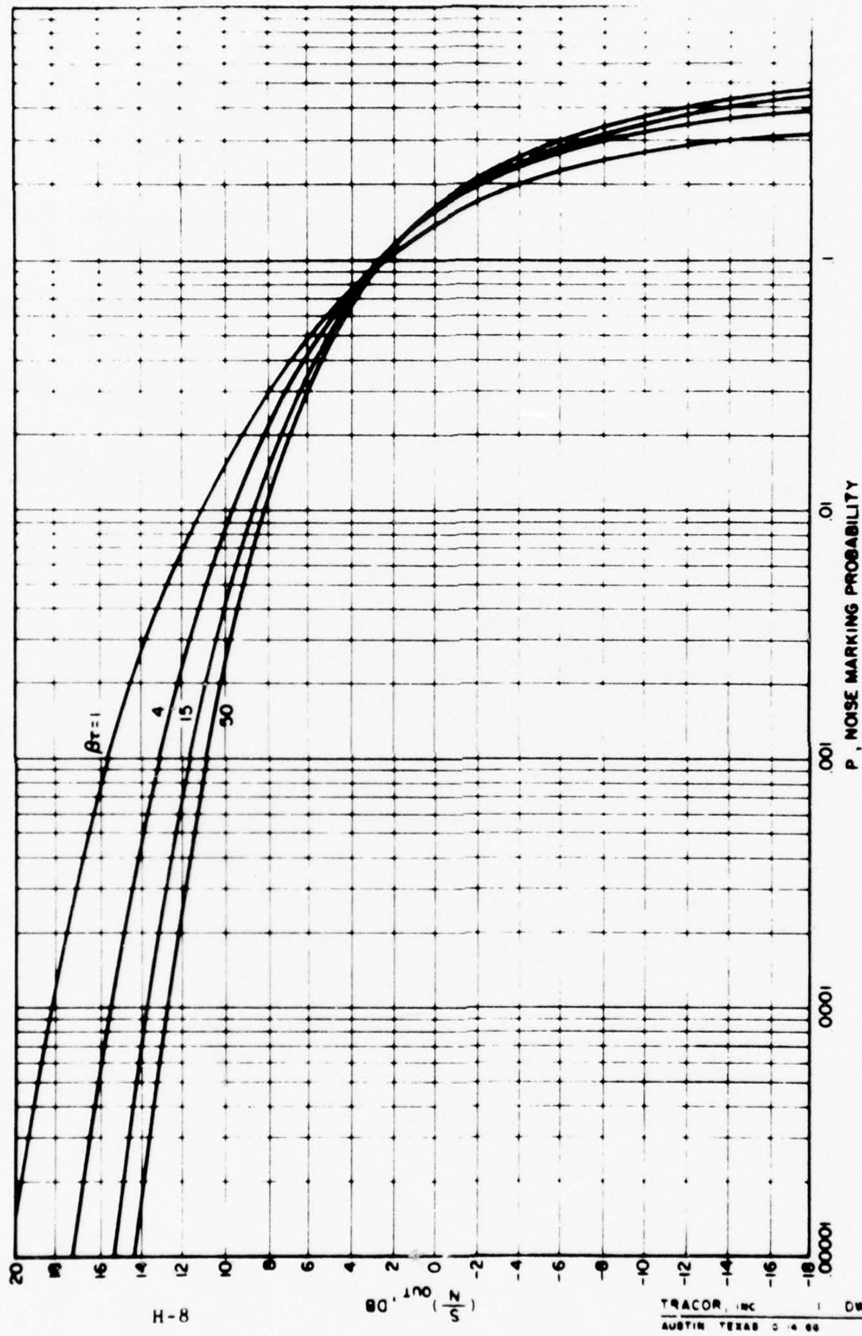


FIG. H-2 - SQUARE LAW DETECTOR AVERAGER $(\frac{S}{N})_{OUT}$ NECESSARY FOR 0.5 PROBABILITY OF DETECTION IN THE PRESENCE OF A GIVEN NOISE MARKING PROBABILITY.

FIGURE 27

Reproduced from TRACOR 66-392-C, Part I,
Tracor, Inc., Austin, Texas

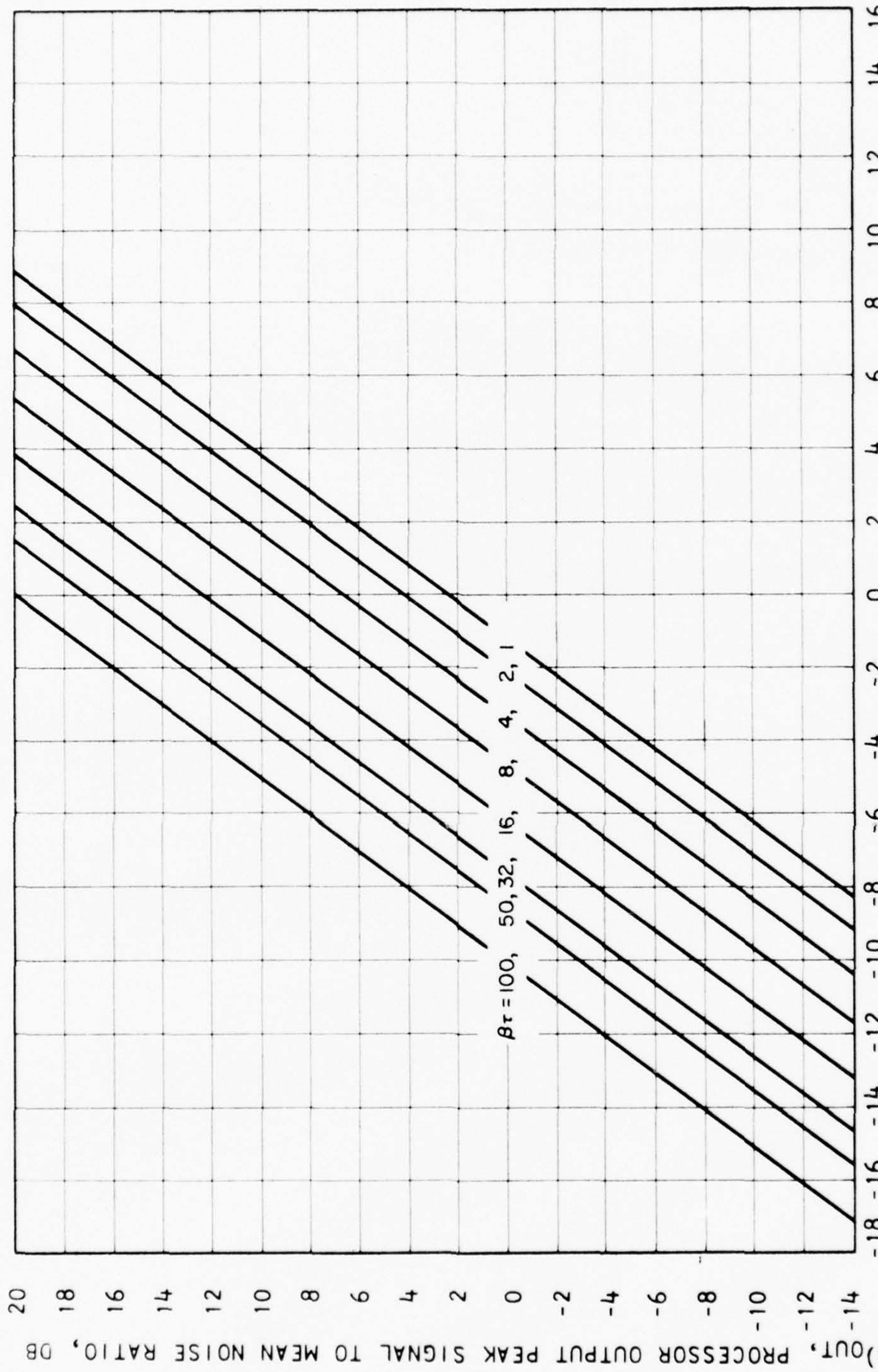


FIG. J-12 - SQUARE LAW DETECTOR AVERAGER SIGNAL TO NOISE RATIO GAIN; SINGLE TUNED CIRCUIT NOISE POWER SPECTRUM

FIGURE 28

TRACOR, INC. DWG 6-23-9
AUSTIN, TEXAS WILKENSON 4-25-66

Reproduced from TRACOR 66-392-C, Part II,
Tracor, Inc., Austin, Texas

AS-69-782

[redacted]

(~~C~~ U) with range (or with reverberation-to-noise ratio). Schulkin and Shaffer in their drawing (shown here as Fig. 18) show a difference in alerted and unalerted figure-of-merit of 28 dB at 2 kyd, decreasing to 15 dB at long range. Fridge uses results from the USS NORFOLK (DL 1) and reports 22 dB difference at 3 kyd and 11 dB at long range. The results reported by Fridge reflect technical evaluation performance, and "semialerted" performance: the operator knows that there is a submarine in the vicinity. The decrease in performance with range is 13 dB in one instance and 11 dB in the other. If for the test results reported here a signal-to-noise ratio of +4 dB is assumed for the "fully alerted" signal differential (audio plus video--see, for example, Ref. 5), a difference of 12 dB in fully alerted and semialerted figure-of-merit can be extrapolated. Our number is dependent on range, and is therefore not consistent with the cited results. (Detection performance for our test was somewhat poorer at midranges; 4 to 8 kyd, due to the increased bottom reverberation at these ranges.)

(U-~~FOUO~~) Another feature of sea detection data which is not present here is the higher percentage of missed detections of targets at all ranges when at sea.

(~~C~~ U) If it is assumed that both the current laboratory and the previous sea measurements are correct, the differences in measured performance may be due to the varying operator response in the respective situations. Four questions which are related to the operator response may be raised:

1) As the operator is scanning the PPI for detections he must scan visually for targets with variable spot size. Does the operator at sea tend to neglect small spot-size targets on his display?

2) In peacetime an operator may need to look at a target for a long period before calling it to the attention of his

U
(~~C~~) Commanding Officer. This is impossible to do when the target is first detected at short ranges. Does the operator have insufficient time to reach his decision to call a target when he first sees the target at short range?

3) In traveling across large stretches of ocean there will be occasions when numerous targets will appear at short ranges. Most of these targets are small in size, but may be very strong reflectors. If the operator is trained to call more short range contacts would a substantially higher (and unacceptable) false alarm rate result?

4) The operator hopes to find targets far out in his range scale. In fact, he is deliberately searching at maximum predicted detection range. Does the operator simply not pay attention to the center, short range portion of his display?

(U-~~FOUO~~) Most of these factors probably act to reduce operator performance at sea; the first and last may be the most important. But in our laboratory tests these effects are not present. We chose to inject a target at a specific range and bearing, and the operators were aware that all ranges were equally probable. Thus, the operator in our "semialerted" detection test was searching the scope in an abnormal manner, that is, a manner different from the postulated operational search. All ranges (and bearings) were given the same attention, in contrast to the expected sea procedure.

U
(~~C~~) The data reported in the first three tests are not in agreement with previously reported results. Some questions raised by this deviation, and some explanations of the differences in measured performance, are offered. The subject merits further attention, especially since the data sample here is small. These data do not verify Fridge's prediction that close-in clutter is responsible for poor short range detection performance.

(U) The implications of this study and the prior work done indicate that there is much potential for both short term and long range improvement in the AN/SQS-23 sonar.

(U) If the cursory study reported here is a true representation of at-sea conditions, sonar operators must be trained to search at close-in ranges, and taught that on a PPI presentation the echo from a near submarine is smaller than that of a more distant target.

(U) The typical target levels for detection imply that a quite simple automatic alarm device could significantly aid in alerting an operator--or the levels for detection imply that emphasis should be given to improving the display to the operator.

(U) This report concludes operator detection tests performed and reported under this contract. Work of this type will be continued under Contract N00024-69-C-1392, which is sponsored by NAVSHIPS, Code PMS-386.

D. <u>Naval Ship Systems Command Active Sonar Classification Advisory Panel</u>
(S. P. Pitt)

(U-[redacted]) Except for participation in the *ad hoc* committee to summarize system design recommendations from exploratory development to systems engineers (see Section III.G.) no formal action was taken by the panel members.

III. Project Serial No. SF 11121100, Task 8515

A. Digital Library
(Systems Analysis)
(S. P. Pitt)

(U-[redacted]) A large part of the manpower effort during the first quarter of CY 69 was spent in the collection of digitized data (submarine data and Lake Travis Test Station (LTTS) data), in cataloging, and in generating or modifying data handling and processing programs. The digital data library has been greatly expanded, primarily with ASPECT data because of the high data rate and good resolution, in anticipation of the parameter extraction studies being implemented for automatic classification. Target behavior studies (specifically, covariance matrix analyses) also require this type of data. A digital data cataloging system that will greatly facilitate data retrieval was established. Systems Analysis intends to publish the contents of this library periodically beginning with the next quarter.

B. Digital Beamformer
(Classification, Systems Analysis, and Computer Applications)
(K. W. Harvel, S. P. Pitt)

(U-[redacted]) A serial sampling and processing system for the AN/SQS-23 was simulated during this quarter. The input to this system was assumed to be the output of the floating-point quantizer described in QPR No. 4 under Contract N00024-68-C-1149 (U). To facilitate binary multiplication for the phase shifting process, it would be desirable to quantize the coefficients (i.e., $W_i \cos\phi_i$ and $W_i \sin\phi_i$, where W_i is the amplitude shading factor and ϕ_i is the desired phase shift) to

(U-[redacted] powers of 2, as the input data are quantized. Multiplication then becomes a shift operation which can be executed very quickly. The remaining hardware problem is converting to binary so that additions can be performed efficiently.

U
([redacted]) The system which has been designed uses the operations just described. To determine the degradation in beams caused by the crude quantizing and serial processing, the system was simulated exactly with the parameters anticipated for the hardware. The resulting patterns for 4.8, 5.0, and 5.2 kHz are shown in Figs. 29 through 31. These can be compared against the "perfect" patterns shown in QPR No. 4 under Contract N00024-68-C-1149 (U). Clearly, the beam distortion introduced by all the coarse arithmetic is not catastrophic. From Fig. 32, it is seen that the phase response at the output of the beamformer follows the input phase closely at the frequencies included here.

(U-[redacted]) The hardware of the digital quadrature beamformer is described below: the parameters used are for forming 48 beams sequentially at a 36 kHz rate. The parameters are based on the AN/SQS-23 system, but the method is directly adaptable to any cylindrical array. Figure 33 shows the method of using the beamformer with the AN/SQS-23. The inputs to the beamformer will be the AN/SQS-23 preamplifier outputs. Figure 34 is a block diagram of the beamformer. The beamformer essentially performs two operations:

(U-[redacted] 1) the beamformer assembles the quadrature components (Ref. 7) of the beam,

$$X = \sum_{i=1}^{16} (X_i \cos\theta_i + Y_i \sin\theta_i) \quad , \qquad (1)$$

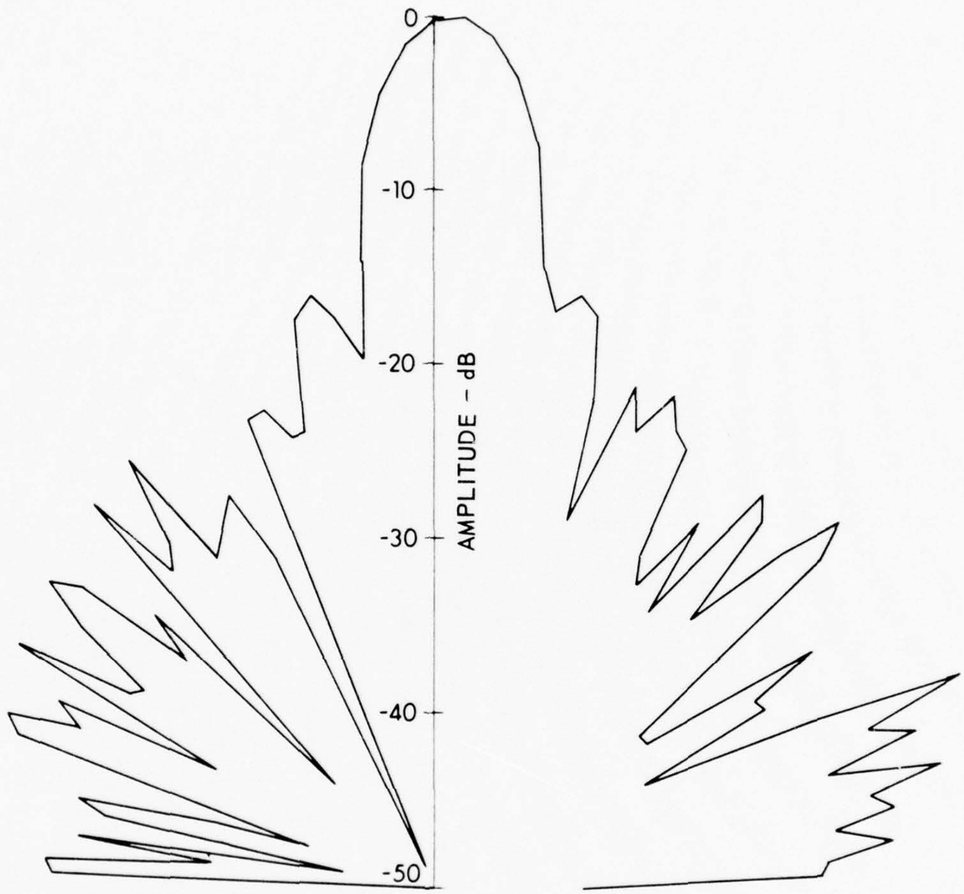


FIGURE 29
DIGITAL QUADRATURE BEAMFORMER USING
FLOATING-POINT QUANTIZATION FOR PHASE AND AMPLITUDE
QUANTIZATION: 1 AMPLITUDE BIT, 5 EXPONENT BITS
FREQUENCY: 4.8 kHz INPUT AMPLITUDE: 1000

ARL - UT
AS-69-587
SPP - RFO
6 - 25 - 69

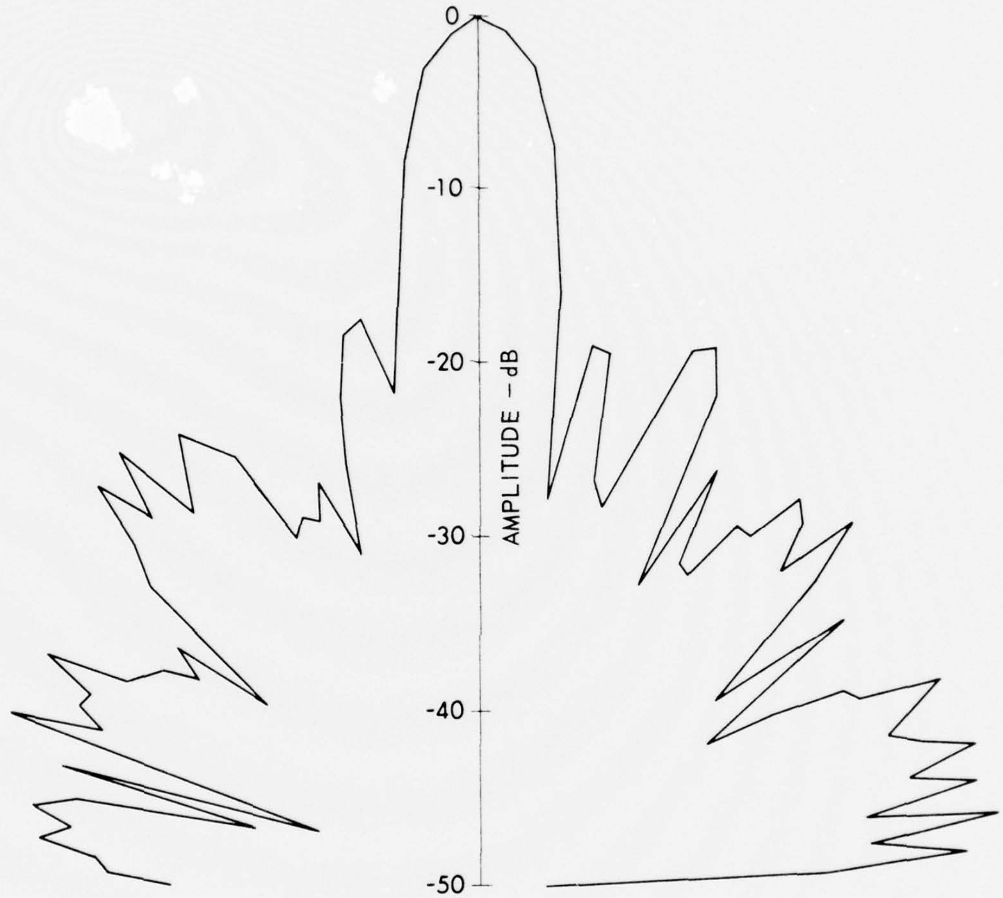


FIGURE 30
DIGITAL QUADRATURE BEAMFORMER USING
FLOATING-POINT QUANTIZATION FOR PHASE AND AMPLITUDE
QUANTIZATION: 1 AMPLITUDE BIT, 5 EXPONENT BITS
FREQUENCY: 5.0 kHz INPUT AMPLITUDE: 1000

ARL - UT
AS-69-588
SPP - RFO
6 - 26 - 69

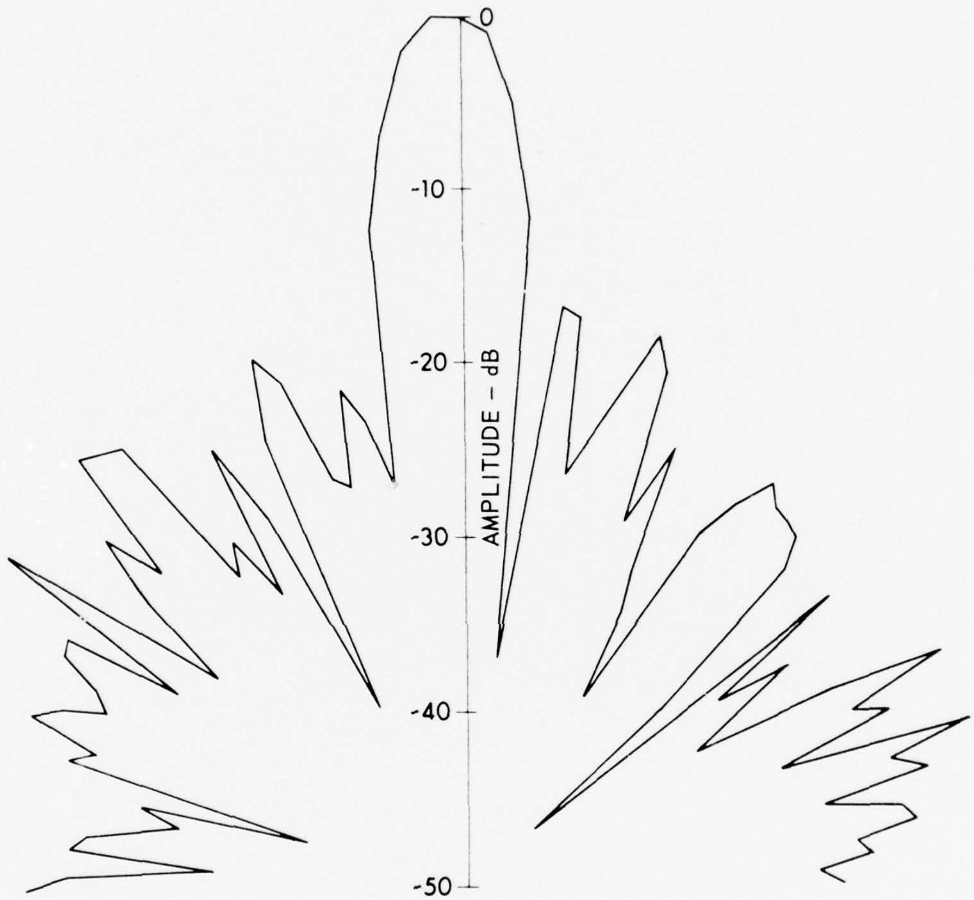


FIGURE 31
DIGITAL QUADRATURE BEAMFORMER USING
FLOATING-POINT QUANTIZATION FOR PHASE AND AMPLITUDE
QUANTIZATION: 1 AMPLITUDE BIT, 5 EXPONENT BITS
FREQUENCY: 5.2 kHz INPUT AMPLITUDE: 1000

ARL - UT
AS - 69 - 589
SPP - RFO
6 - 26 - 69

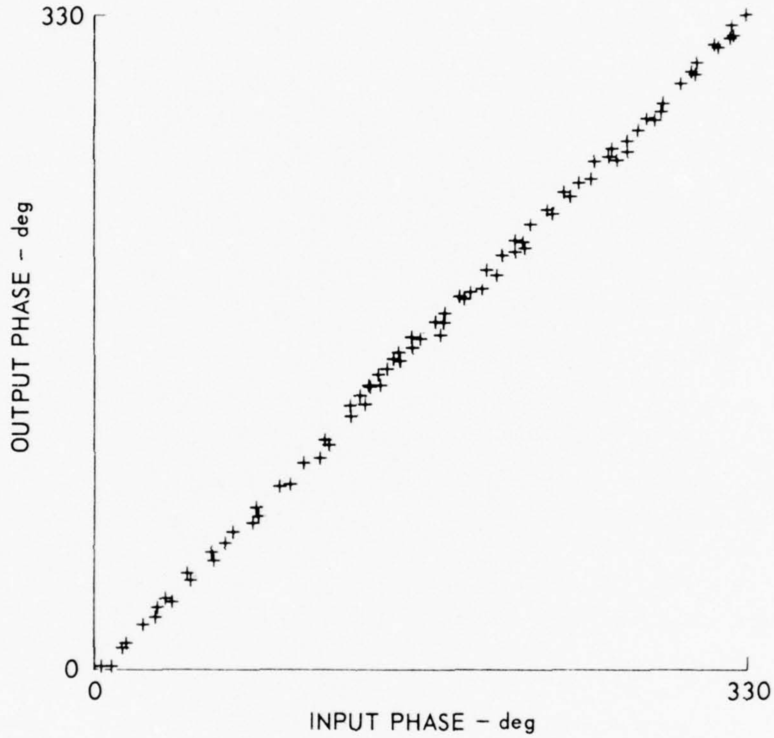


FIGURE 32
PHASE RESPONSE OF DIGITAL QUADRATURE BEAMFORMER FOR LINEAR FM SLIDE INPUT
FM SLIDE: 4687.5 Hz TO 5312.5 Hz IN 102.4 msec
QUANTIZATION: 1 AMPLITUDE BIT, 5 EXPONENT BITS
INPUT AMPLITUDE: 1000

ARL - UT
AS-69-590
SPP - RFO
6 - 26 - 69

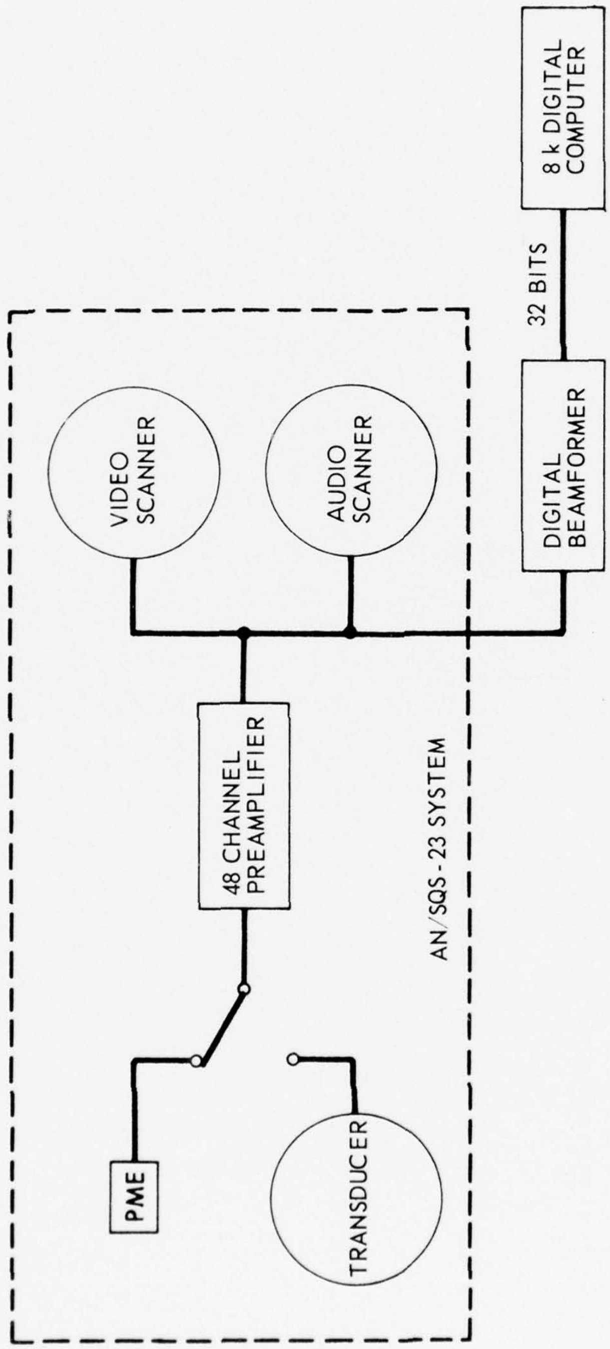


FIGURE 33
INTEGRATION OF BEAMFORMER WITH THE AN/SQS-23

ARL - UT
AS-69-783
KWH - JEW
7 - 30 - 69

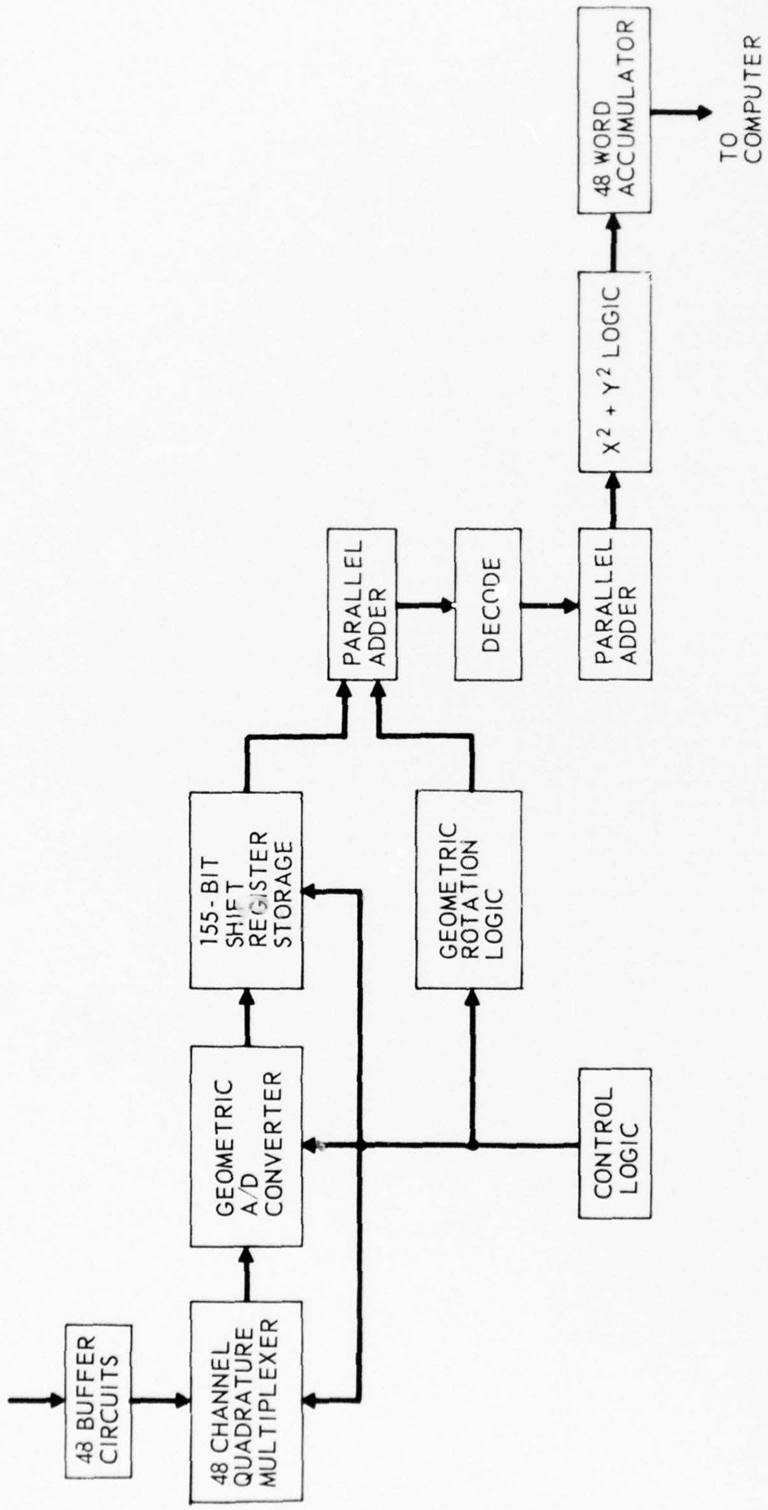


FIGURE 34
BEAMFORMER BLOCK DIAGRAM

ARL - UT
AS-69-784
KWH - JEW
7 - 30 - 69

[redacted]

(U-[redacted])

$$Y = \sum_{i=1}^{16} (X_i \sin\theta_i - Y_i \cos\theta_i) \quad , \qquad (2)$$

(U-[redacted]) (2) the output logic forms the sum of squares of X and Y, and then takes an average of these components over 16 msec.

(U-[redacted]) In order to obtain the instantaneous components of the beam (X_i and Y_i, of Eqs. (1) and (2)) the analog-to-digital converter samples each stave 90 deg apart in phase, for each sample from the quadrature multiplexer (Refs. 6 and 7). The multiplexer switching rate is 36 kHz (determined by the AN/SQS-23 preamplifier 18 kHz frequency), and the geometric A/D converter samples at a rate of 72 kHz. Five bits in the geometric format provide 90 dB of converter dynamic range.

(U-[redacted]) The control logic enters the samples of the staves into five 31-bit shift registers which are wired as recirculating memories. Each stave sample is used 16 times to contribute to 16 beams. Each quadrature sample is rotated by the appropriate angle, as can be seen in Eqs. (1) and (2), by multiplying by $\pm\cos\theta_i$ and $\pm\sin\theta_i$, to form the four products ($X_i\cos\theta_i$, $X_i\sin\theta_i$, $Y_i\sin\theta_i$, and $-Y_i\cos\theta$, in that order). Since the individual components are in geometrical format, a parallel adder can perform the multiplication in gate switching time (about 60 μsec). The words in geometrical format are decoded to give 2's complement binary form. The summations needed to give the quadrature components X and Y are accomplished by a parallel adder and two storage registers. The input frequency of the adder is 2.304 MHz. Since the two quadrature components are formed from 64 different products, the output data rate gives both quadrature components at a 36 kHz rate. (Left half and right half beams are generated by the first 8 and last 8 terms in Eqs. (1) and (2) respectively, but are not outputted in this beamformer.)

(U[redacted] The output logic of the beamformer sequentially squares each of the quadrature components and sums these squares. An output accumulator sums twelve groups of 48 words to give a 16 msec average on each beam. After the averaging process is completed, the 48 words are buffered into a computer for normalization. The 16 msec average is accomplished in the special purpose hardware to reduce the input data rate to the computer.

(U[redacted] To further demonstrate the usefulness of the technique a beamformer of the type described will be built and tested with the AN/SQS-23 Playback System at ARL. The digital portion of the beamformer is simple, small, and straightforward to build. The input multiplex switch will probably limit the dynamic range of the beamformer. The A/D converter has only 32 states, and the speeds required are readily obtainable with 32 parallel integrated circuit voltage comparators.

(U-[redacted] To fully observe the usefulness of a digital system of this type it is necessary to process the beamformed data for display and detection. The computational procedure which has been analyzed for immediate programming locates areas that contain a larger than average signal level. These areas must be localized in both range and bearing for the computer to respond to the signals. Twenty-four samples of each beam output (representing a 0.384 sec history) are stored in memory, in a 24 by 48 word array. A sequential testing procedure may be used to evaluate the presence or absence of a target in each bearing cell across the center of this array, as shown in Fig. 33. At the new data sample time (after the beamformer has accumulated a 16 msec average) the array is updated and the test is repeated. Several criteria can be used to accomplish the normalization, but no study has yet been performed to determine the relative merits of each. The procedure diagrammed in Fig. 33 is one of the more complicated, but even so it is readily handled by a small fast computer.

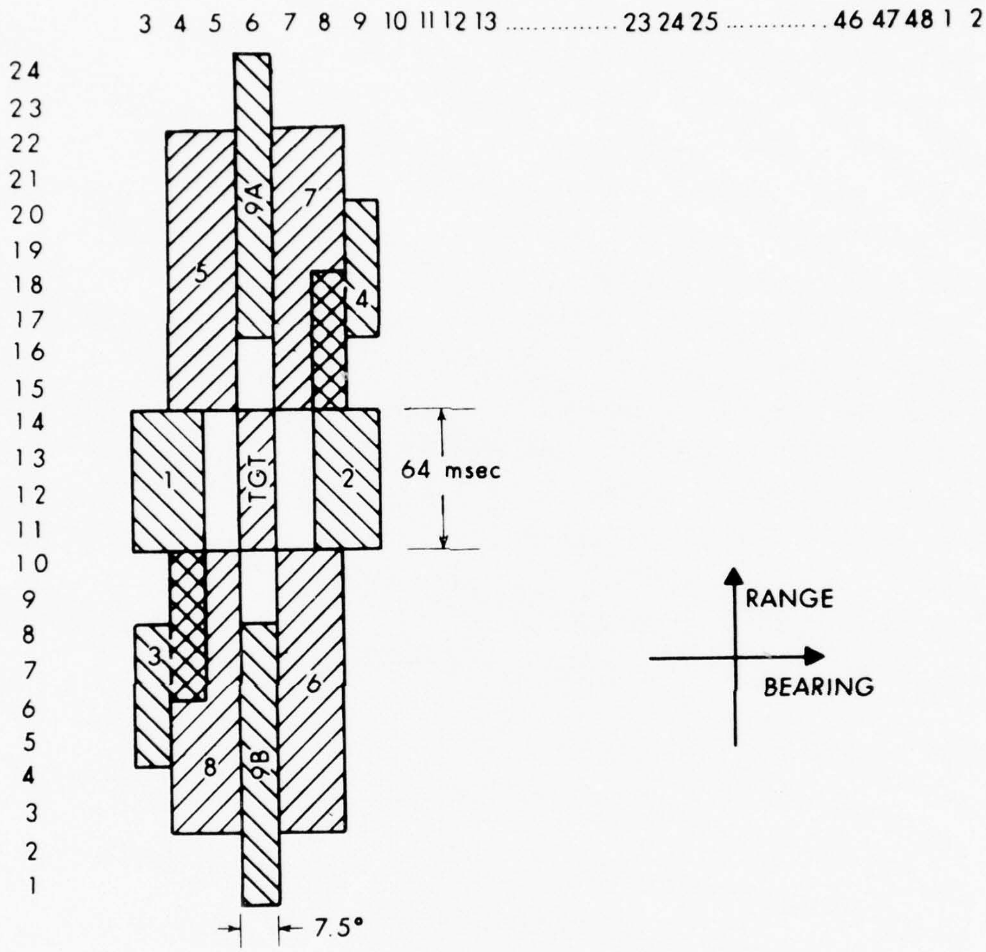


FIGURE 35
TEST ARRAY

ARL - UT
AS-69-785
KWH - JEW
7-31-69

[redacted]

(U-[redacted]) The selected target is shown on bearing 6 in Fig. 35. The first step of the procedure is to add the four cells labeled "target" (representing 64 msec in range, this being controlled by the 30 msec transmit pulse). Then this value is scaled with an operator adjustable input threshold control. The area labeled "1" is added together and tested against the scaled target area. If the scaled target area is less than the sum of area 1, then the target is not localized in bearing and the test is discontinued. If it is greater than 1, test 2 is tried, etc. Areas 3 and 4 are selected to cancel the effects of reverberation from an RDT transmission, and are not needed when only ODT transmissions are used. Areas 5, 6, 7, and 8 further determine that the target is localized. Area 9 is split into two areas for the purpose of providing split window normalization. If the average value of the target is sufficiently large to pass all of these tests the signal-to-background ratio is calculated, using Area 9 for the background, and range, bearing, and signal-to-background are stored for further use. These may be used for further computer processing for automatic detection, or used for direct display.

(U-[redacted]) The number of computations required is large. All nine tests can be accomplished for the 48 beams with approximately the following instructions:

Add instructions	5808
Store instructions	98
Compare instructions	480
Clear instructions	432

Accomplishing these instructions in real time allows about 1.9 sec per instruction. However, it is clear that all 72 by 9 tests are not required. Any time any test is passed it is necessarily required that several others will fail,* and any test that fails saves

*If a test is passed for one range cell, it is necessary that the complement must fail.

[redacted]

(U-[redacted]) computation steps. A computer reduction lead of at least a factor of 3 will result from this consideration.

C. Floating-Point Correlator
(Classification, Systems Analysis, and Computer Applications)
(S. P. Pitt)

U ([redacted]) Data analysis was finally completed during this quarter and appendixes describing the computer processing were added to K. W. Harvel's text for the report on the floating-point technique. The report was thus essentially completed during this quarter, and it will be published in the next quarter as ARL-TM-69-5 (Ref. 8). The essential conclusion of this report is that, at least for TW products of 32 or greater, no degradation is suffered in the envelope of the output of a correlator when binary floating-point representation (with sign only amplitude quantization) is employed, whereas the useful dynamic range is increased many fold over the same process using linear quantization. The hardware implications to real time digital systems are extensive, especially in wide dynamic range applications such as echo ranging sonar.

D. Quadrature Sampling
(Systems Analysis)
(S. P. Pitt)

U ([redacted]) Two publications concerning quadrature sampling are presently in preparation. The first treats the problem of discrete sampling of waveforms in a general way, and thereby develops a "generalized" quadrature sampling formula. A practical result of the treatment is the development of the quadrature sampling formula for low pass waveforms, so that it has been proved that samples of the quadrature components of waveforms with any bandlimited spectra can be obtained.

U ([redacted]) The second publication in preparation concerns the digital computation of Fourier transforms of bandlimited waveforms through

(U[redacted]) their quadrature components, a process which reduces the number of samples required to obtain spectra. This quadrature method is compared to first-order sampling methods for processing high frequency waveforms at low sampling rates.

E. Other Publications
(S. P. Pitt)

(U-[redacted]) A dissertation developed from the likelihood ratio processing study will be published in technical report form after suitable editing and additions; and a condensed, unclassified version will be submitted for publication in the open literature. The formal document as dissertation is in the final stages of preparation in the Technical Reports Office.

(U-[redacted]) The report describing an analytical method for studying the properties of reverberation was published in this quarter. Work is continuing, both in developing and analyzing reverberation data.

(U-[redacted]) The only delay in publishing the guideline report for automatic classification is the collation of the two parts, written by different people, describing the real-world problem and the technological problem. This report is expected out this quarter.

F. Software Development
(ComputerApplications)
(J. K. Vaughan)

(U-[redacted]) New programs and new modifications of old programs generated during this quarter are described in this section and in the appendix. A new general purpose plotting program was completed during the past quarter. The options include:

(U-[redacted]) Data FORMAT Options:

1) Plot the X vs Y quadrature components of a uniformly sampled array
2) Plot one input record vs another, e.g., R vs θ for a polar plot
3) One array vs sample number

Plotting Options:

1) Single plot or family of curves per set of axis
2) Envelope of quadrature components of X vs Y quadrature component
3) Line Ω point plot
4) Four different symbols if point plot

(U-[redacted]) The program MODSUB has been modified. Originally the program simulated a signal which would be received from a set of point reflectors on a straight line. The additions to the program include options for the following items:

1) a second line target consisting of a set of point reflectors,
2) a second receiving hydrophone,
3) straight line motion for the line arrays.

(U-[redacted]) The program SIGGER was developed to separate multipath data into the direct and reflected or refracted signals. Quadrature or uniformly sampled data may be used as inputs. In either case, the time delay between the paths is derived from a comparison of major peaks of the autocorrelation function.

(U-[redacted]) Modifications have been made to the A/D program, and work is nearing completion on the new general purpose A/D conversion program. The capabilities of the new A/D program are outlined in the appendix. The primary modification of the current A/D program was the addition of real time quadrature sampling. The real time sampling technique allows for the storage of every nth set of quadrature components only,

(U-[redacted]) thereby not wasting storage for unwanted samples, and allowing longer sets of data to be digitized. For example, if data were being digitized at a rate of 20 kHz, only 1.25 sec of data could be digitized before the modification; whereas after the modification, 10.0 sec of data could be digitized at a rate of 1250 samples/sec on each quadrature component.

(U[redacted]) Improvements have been made not only in the A/D programs but also in the A/D-D/A facilities of the Laboratory. A new A/D-D/A interface, which includes a patch panel, has been installed. The patch panel provides interfacing to the CDC 3286/3288 conversion controller and the interconnection of the various equipments listed below:

1	Ampex FR1800 analog tape recorder
2	Tektronix RM 565 oscilloscopes
1	Daytronics 718 variable bandpass filter
4	Krohn-Hite 3200 variable filters
1	ARL filter bank, which includes several low-pass and bandpass filters
1	Hewlett-Packard 3300A signal generator
1	Krohn-Hite 440A oscillator
1	Hewlett-Packard 204B test oscillator
1	Sample pulse generator
1	Systron-Donner 1033 Universal counter-timer
1	Beckman 4910P digital voltmeter
1	Ballantine 300G ac voltmeter
2	Hewlett-Packard 350D attenuators
2	ARL signal conditioning interfaces which include:

4 attenuators
4 buffer amplifiers
1 adder
1 detector
4 power amplifiers

G. Trips
(S. P. Pitt)

(U-[redacted]) On 17 February 1969, Messrs. S. P. Pitt and J. K. Vaughan traveled to San Diego, California, to meet with representatives of three different groups. The first day was spent primarily with Mr. B. Pennoyer of Naval Undersea Research and Development Center (NURDC), Code 554. The discussions concerned the publication of the joint report on PAIR which has been so long in preparation. The second day was spent alternately with NURDC, Code D606, personnel and Dr. H. Kramer, formerly with General Electric, TEMPO, Santa Barbara. A trip report dated 11 March 1969 details the results of these meetings.

(U-[redacted]) From 31 March through 4 April, Mr. Pitt was in Washington, D. C., to participate in an *ad hoc* committee to prepare a report detailing recommendations to "systems designers" as a result of exploratory development either completed or still in progress. The work of the committee will eventually become a document describing the "best" system exploratory development could produce now, the anticipated best system which would be produced one year from now and, again, two years from now; this document is being prepared by individual committee members. The final version will be produced by Naval Ship Systems Command personnel from the committee members inputs. The organizations represented at the meeting were USNUSL, NURDC, NSRDC, NAVSHIPS, and ARL.

H. Visitors
(S. P. Pitt)

(U-[redacted]) On 29 and 30 January 1969, Messrs. K. Buske and D. Strickler, Naval Ship Systems Command, visited ARL for an informal review of work in progress and anticipated work. Most of the detailed discussion with Systems Analysis and Computer Applications revolved

[redacted]

(U[redacted]) around the digital beamformer and the floating-point correlator and their applications to detection and classification systems. The PAIR system and the automatic classification system that are to be developed were also discussed. Most of the discussions were fairly general because of the limited time. A similar meeting will be held during the next quarter.

(U-[redacted]) On 10 March 1969, Dr. David Middleton made a consulting visit to ARL. His recent work includes a technical memorandum describing the application of statistical techniques and terminology to real, physical problems. A rough draft of the memorandum was left for comments and suggestions. Most of discussions with Systems Analysis involved the use of Dr. Middleton's analytic model for reverberation on both sea and lake (model) data, and the establishment of a statistical relationship between the two. This relationship will be studied during the next quarter.

I. <u>Short Course at The University of Texas at Austin (S. P. Pitt)</u>

(U-[redacted]) Messrs. T. D. Plemons, J. F. Hoffman, and S. K. Mitchell attended sessions in a short course on communications engineering applied to radar, sonar, and seismology, presented by The University of Texas at Austin during the period 24 March through 3 April 1969. Dr. Middleton, Dr. W. D. Gregg, and Dr. G. J. Gruber were the instructors for the course, which was an introductory course on past and recent problems in these areas that have been treated by communications engineers. The course was well attended by engineers and scientists from various parts of the country.

REFERENCES

1. Morris Schulkin and R. L. Shaffer, "Active Sonar Range Prediction for Surface Sound Channel Propagation" (U), Naval Ordnance Laboratory, SAG Report 67-8, November 1967. (CONFIDENTIAL)

2. H. E. Fridge, "An Analysis of AN/SQS-23 Sonar System Performance and A Related Performance Prediction Model" (U), USNUSL Technical Memorandum No. 2040-061-67, U. S. Navy Underwater Sound Laboratory, Fort Trumbull, New London, Connecticut (25 August 1967). (CONFIDENTIAL)

3. J. F. Wilkinson, "Summary Report, Reformulation of the Sonar Equations" (U), Tracor 66-392-C (Part I), Tracor, Inc., Austin, Texas (8 July 1966).

4. J. F. Wilkinson, "Summary Report, Reformulation of the Sonar Equations" (U), Tracor 66-392-C (Part II), Tracor, Inc., Austin, Texas (8 July 1966). (CONFIDENTIAL)

5. Quarterly Progress Report No. 4 under Contract N00024-68-C-1149 (U), 1 October - 31 December 1968, Applied Research Laboratories, The University of Texas at Austin, Austin, Texas, Fig. 2. (CONFIDENTIAL)

6. S. P. Pitt and O. D. Grace, "Signal Processing by Digital Quadrature Techniques," Defense Research Laboratory Technical Report No. 68-39 (DRL-TR-68-39), Applied Research Laboratories, The University of Texas at Austin, Austin, Texas (30 December 1968).

7. S. P. Pitt and O. D. Grace, "Quadrature Sampling of High-Frequency Waveforms," J. Acoust. Soc. Am. <u>44</u>, November 1968, pp. 1453-1454.

8. K. W. Harvel, J. K. Vaughan, and S. P. Pitt, "Wide Dynamic Range Correlator for Envelope Preservation--A Floating-Point Technique," Applied Research Laboratories Technical Memorandum No. 69-5 (ARL-TM-69-5) in preparation at Applied Research Laboratories.

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[redacted]

APPENDIX

(U-[redacted]) The programs summarized below are those with current applications, and therefore this list is only a partial listing of the total program library.

A. A/D-D/A Programs

1. A/D

(U-[redacted]) Due to its versatility and real time capabilities, this program is used for all analog-to-digital conversion. In that the A/D is the first step of processing data recorded on analog tapes, it sets format for the digital tapes that all subsequent programs must follow, and is therefore described in more detail than the other programs. The following options are under program and operator control:

a. Sampling Options

1) Quadrature sampling for every nth sync pulse

2) Uniform sampling

b. Operating Mode Options
(with any sampling or sample size option)

1) Single channel random access mode

2) Multichannel (≤8) incremental mode

3) Two channel simultaneous sample and hold

c. Sample Size Options
(with any operating mode or sampling option)

1) Variable length (≤25,000 samples per signal)

2) Continuous - no limit on the number of consecutive samples, but output is as many 5000 word (packed two samples/word)

[redacted]

(U-[redacted]) records as required. The maximum conversion rate in this mode is approximately 22,500 samples/sec.

d. Digital-to-analog conversion of input: This option is available only with sampling option 2), operating modes 1) and 3), and sample size option 1).

e. Operator Control

1) Start digitization process with the next interrupt
2) Write EOF and exit program
3) Search digital tape for a particular record
4) Backspace digital tape
5) Read new data card
6) Reset sequence count
7) Search for end-of-file on digital tape
8) Start over, rewind output tapes

([redacted]) 2. DISPLAY: This is a digital-to-analog conversion program which inputs data from digital tapes and recirculates computer memory to the D/A interface.

(U-[redacted]) 3. TRACE4: This is a program for digital-to-analog conversion. A maximum of four signals may be displayed. Any of the signals may be rectified or shifted in time relative to one another. Many operator options are provided on the ARL A/D-D/A interface. The program may be used to simulate some of the effects of Doppler.

B. Data Processing Program

(U-[redacted]) 1. QUADBUFF: Although a subroutine in reality, this real time I/O routine deserves mention at this point since nearly all programs described below use this routine. Its flexibility and capability

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(U-[redacted]) allow several input options. The subprogram reads integer data from digital tape with the following options:

a. Beginning and ending sample of the physical record may be specified for input to core storage, thereby saving computer storage if the entire record is not required, or allowing any portions of a record to be read even if the physical record is larger than the computer storage.

b. Input only every nth sample point.

c. Quadrature sample uniform data, storing the input into two arrays for the X and Y quadrature components.

d. Rectify the input data.

(U-[redacted]) 2. ADNOISE: This program inputs two records from digital tapes, scales the second record, and adds the two records. The program is useful for studying the effects of various S/N ratios on different processes.

(U-[redacted]) 3. BEAMFORM: This program is designed to simulate quadrature digital beamforming. The options include the following:

a. Input: Digitized output of staves (16 or fewer staves) or analytically generated data which includes one or two signals from one or two directions. Each signal consisting of a maximum of 50 point reflectors having variable amplitudes and time delays.

b. Quantizing: Floating-point or N-bit linear quantization may be simulated.

c. Sample Rate: Variable.

d. Stave Sampling Order: May be specified to simulate various multiplexer designs.

e. Weighting: May be changed to simulate different systems.

f. Beam Shading: May be changed to simulate any given array geometry.

g. Scale: The analytic signal(s) may be scaled to any predetermined maximum value.

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(U-[redacted]) 4. COPYTAPE: Basically the program transfers records from as many as three input tapes onto a fourth tape. The program is used to release digital tapes for further use while retaining the information. The options are flexible, allowing any portion of the desired input records to be transferred using the capabilities of subroutine QUADBUFF.

(U-[redacted]) 5. CROSCORG: This is a general purpose crosscorrelation program. The equation used is

$$C_t = \sum_1 (x_i)(y_{i+t}) \quad .$$

The program includes options for the simulation of different sampling rate and of floating-point or N-bit linear quantization.

(U-[redacted]) 6. DATASTAT: Designed to compute the ensemble mean and variance of the envelopes of a series of signals. The program has options to quadrature sample the data, to determine the threshold of each signal as a function of maximum value, align the signals according to the different thresholds and plot the aligned signals.

(U-[redacted]) 7. DOLFDATA: This program processes a 5000-word data block (packed two samples/word) from digital tapes to produce an output record each time some predetermined threshold is exceeded. The length of the output record is predetermined by the number of samples desired either side of the threshold. This program is useful when processing data from the continuous mode of the program A/D; e.g., when time integrity must be maintained but the sample size is too large for the computer memory.

(U-[redacted]) 8. ENCOR: Correlates the envelope of a signal against the envelopes of a series of signals. The resulting correlations may be plotted and/or buffered onto digital tapes for further processing.

(U-[redacted]) 9. ENSEMBLE: Calculates the correlation function between two ensembles of time functions by ensemble averaging rather than time averaging.

(U-[redacted]) 10. EPOCH: Used primarily as an editing program for locating a signal within a record. The program determines the beginning and ending samples which exceed a threshold specified as a fraction of the maximum sample value. Either the original input signal and/or signal envelope may be used.

(U-[redacted]) 11. FASTPOWR: This program computes the power spectra for a signal which has been uniformly or quadrature sampled. The power spectra for data which have been uniformly sampled may be obtained by first selecting the quadrature components before computation or by taking the Fourier transform of the autocorrelation function. The fast Fourier transform is used in this program.

(U-[redacted]) 12. LISTAPES: Lists any portion of data records from any of four input tapes.

(U-[redacted]) 13. MATCOR: Used to compute a covariance matrix. The program inputs an ensemble of records from digital tapes and correlates each record with itself and the other records. The computation may be uniform or quadrature correlation.

(U-[redacted]) 14. MODSUB: This program simulates a sonar return from an analytically generated cw or LFM transmit signal. The target consists of two line arrays, each with as many as 100 point reflectors of varying attenuation and time delays. The target can have straight line motion relative to a stationary receiving system. The receiving system may consist of one or two hydrophones.

(U-[redacted]) 15. NEWPLOT: Plots signals recorded on digital tapes.

(U-[redacted] 16. <u>POWERPTS</u>: Computes the power spectrum of a signal by obtaining the Fourier transform of the autocorrelation function.

(U-[redacted] 17. <u>PROBDEN</u>: For a given input signal, the program computes the amplitude density function for a given interval size, mean, variance, skew, and kurtosis. The histogram and normal distribution curve are plotted.

(U-[redacted] 18. <u>PROVERB</u>: This program computes and plots the variance of N sampled values of a signal vs a lag interval. In this manner the variance for a given function is calculated as a function of time.

(U-[redacted] 19. <u>QUAD</u>: Quadrature samples and outputs on digital tapes data which have been uniformly sampled.

(U-[redacted] 20. <u>QUADCORR</u>: A general purpose program for quadrature correlation.

<u>Input Options</u>:

a. Uniformly sampled data

b. Data sampled in quadrature

<u>Quantizing Options</u>:

a. Floating-point quantization

b. N-bit linear quantization

<u>Scaling</u>: Input data may be scaled to any predetermined maximum.

(U-[redacted] 21. <u>RAVEN</u>: Computes the ensemble variance of a series of signals.

(U-[redacted] 22. <u>RECARD</u>: Reproduces a source deck with correct sequencing in the comment columns 73-80.

(U-[redacted] 23. RESTATE: This program is used to "clean up" and reproduce a FORTRAN source deck. The cleanup procedure includes sequencing the deck in the comment columns 73-80, and relabeling statement numbers such that they occur in an ascending order. References to the statement numbers are changed accordingly.

(U-[redacted] 24. SIGGER: This program was developed to separate multipath data into the direct and reflected or refracted signals. Quadrature or uniformly sampled data may be used as inputs. With either input, the time lag between paths is derived by comparison of the major peaks of the autocorrelation function.

(U-[redacted] 25. SPLIT: This program outputs a record on digital tape for each channel of data whose samples have been multiplexed onto a digital tape.

(U-[redacted] 26. SPLOT: A general purpose plotting program which accepts either fixed-point or floating-point data from magnetic tapes.

(U-[redacted] 27. XYPLOT: This plotting program meets the requirements of most all applications. The options include:

Data FORMAT Options:

a. Plot the X vs Y quadrature components of a uniformly sampled signal.

b. Plot one input record vs another; e.g., R and θ for a polar plot or the X and Y quadrature components of data sampled in quadrature.

c. One array vs sample number.

(U-[redacted]) Plotting Options:

a. Single plot or family of curves per set of axis

b. Envelope of quadrature components or Y-component vs the X-component

c. Line or point plot

d. Four different symbols if point plot option selected

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